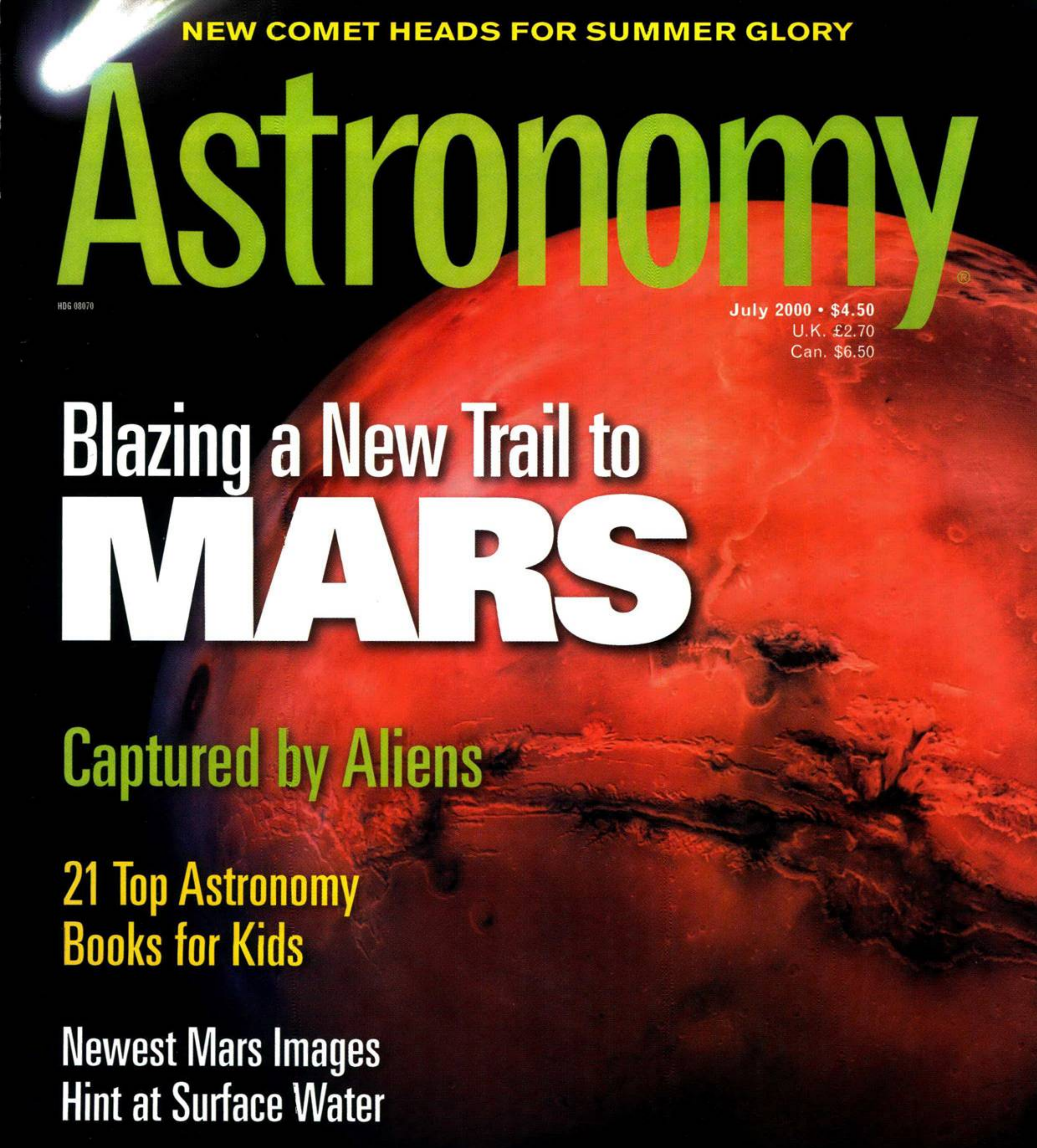

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"...Viewing a 2nd-magnitude star at high power [the 8" LX200] showed a nearly textbook-perfect image...I do indeed rank these optics as diffraction limited...Jupiter and Saturn exhibited riveting detail... During the November 10, 1997, triple shadow transit on Jupiter, the LX200 was my telescope of choice. It showed all three moon shadows as plainly different in size and shading, a rare and remarkable sight. Under the automatic GO TO command, the LX200 routinely placed objects, including the Moon and planets, within 1 to 4 arc-minutes of the center of the field. Not only was it accurate — it was fast. The LX200 usually took no longer than 10 to 25 seconds to slew to and center an object...The latest major feature added to the system is what Meade calls High Precision Pointing. When this is activated...Meade promises a pointing accuracy of 1 arc-minute. I can confirm this amazing figure. Objects consistently ended up within 1 to 2 arc-minutes of the field's center, a great aid to CCD imaging of faint targets...if you know what you want to look at, the LX200 will find it with astonishing speed and accuracy...the telescope I tested provided excellent performance in all critical areas while adding a level of technical luxury that is truly powerful and impressive...I have absolutely no hesitation in recommending the LX200 series...After having used the LX200 for several months, I can attest to the wonderful hands-off convenience and sheer fun of the motorized GO TO." — **from the review in *Sky & Telescope,* April, 1998.**

"The [10" LX200] telescope's optics, stability, and tracking accuracy — all of which are crucial in my applications — are truly remarkable, fully up to the demands that my photographic program requires. My LX200 is now nearly four years old, and during that time it has received heavy use, including 2000-mile round trips to southern France four times a year. The telescope is everything I could possibly have expected it to be." — **Philip Perkins, Wiltshire, England**

The Whirlpool Galaxy (M51) in Canes Venatici.
A 10" LX200 photo by Philip Perkins; two 120-minute exposures were digitally combined to obtain the final image.

"The view through the [7" LX200] system is superb, with pin sharp images right across the field and absolutely no trace of achromatism. Moving to higher powers reveals stellar images constrained only by the seeing and limitations of diffraction.... This telescope is, by any standards, a most powerful observing system.... If you were to sit down and write a specification based on unbridled optimism and imagination, I doubt whether you would come up with all of the features available on the LX200 series. This telescope really has to be experienced." — **from the review in *Astronomy Now (U.K.),* November, 1996, by Bob Neville, Director, Instruments and Imaging Section, British Astronomical Association.**

"The optics of my 12" LX200 are exquisite — in fact the best optics in a commercial catadioptric telescope that I have ever looked through. At 500X the Epsilon Lyrae double-double is not only clearly split into four components, but each of the four stars exhibits a textbook-perfect diffraction pattern, the ultimate test for superior optics." **— Jack Newton, Chiefland, FL.**

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

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10" LX200 Schmidt-Cassegrain	**2695.**
12" LX200 Schmidt-Cassegrain	**3995.**
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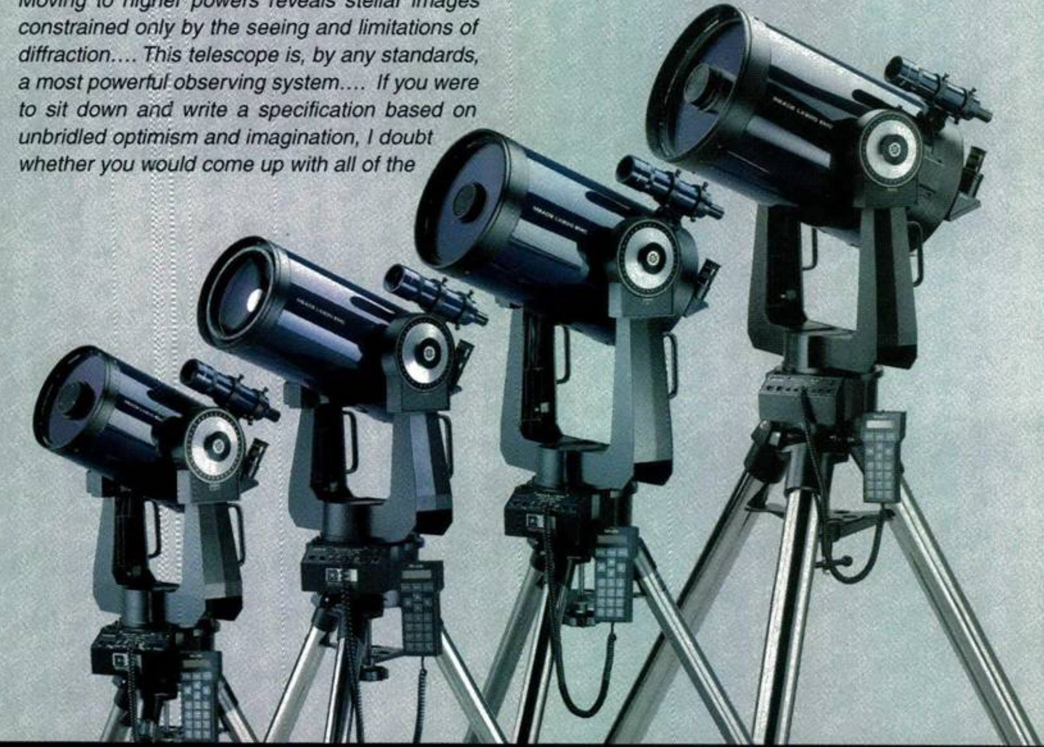
Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125. Prices shown are suggested U.S. mail-order retail prices and are effective March 15, 2000.



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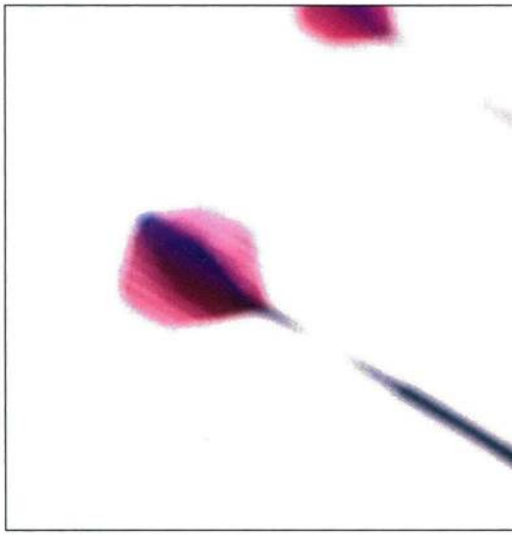

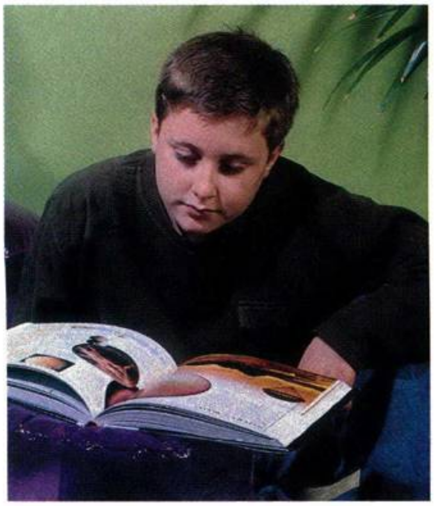

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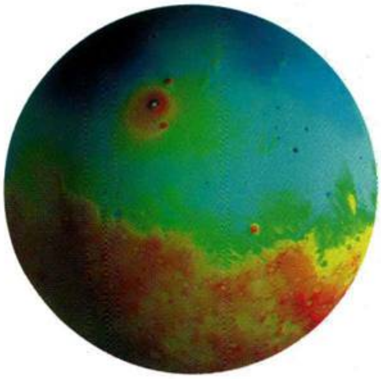

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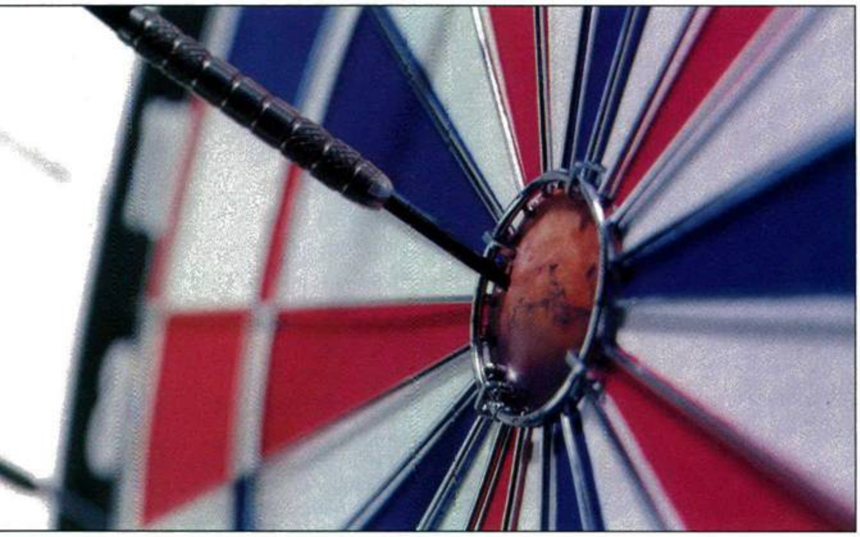

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

A Thoroughly Martian Issue

Eighteen pages of this issue are devoted to stories about Mars and our effort to understand the Red Planet. I should probably take credit for a perfect plan, but I just can't. Note: No cover blurb reading "Special Issue on Mars." Due to the serendipitous mix of chaos and alchemy that often go into making a magazine, we have produced a special issue without even trying.

Of course we knew we had a story or two about Mars. But two of these derived from slightly different plots, and one leaped upon us in the last minutes of production. A story about NASA's goofs evolved into "Blazing a New Trail to Mars" (page 48). When we finally decided on what chapter to excerpt from Joel Achenbach's hilarious book *Captured by Aliens* (page 42), it just had to be the slightly jaundiced look at the founding of the Mars Society. Then, suddenly, we couldn't postpone a late-breaking piece by planetary scientist Bill Hartmann on new findings that point to water rushing around under martian soil (page 36).

Astronomy: Jim Forbes

Beth Weissgerber

Then again, it's not entirely accidental that there's a lot to say about Mars these days. Some readers tell us they'd like a whole magazine focused on that planet every month.

And it's no accident at all that graphic designer Beth Weissgerber has joined our art department. Our new designer competed with several other highly talented candidates for this spot and is already proving herself worth much more than her minuscule weight. Beth, a native of Kenosha, Wisconsin, studied art and design at the University of Wisconsin-Milwaukee and spent part of her junior year in Paris.

She has a fish named Oscar and loves to swim, waterski, play her oboe, read, and walk around aimlessly on warm days. On June 17, 2000, she is set to marry another company employee, Kalmbach Publishing's computer jockey Brian Wesselhoff. She won't even have to change the monograms on her blazers.

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SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

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Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	375.

The 120-page Meade General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers.
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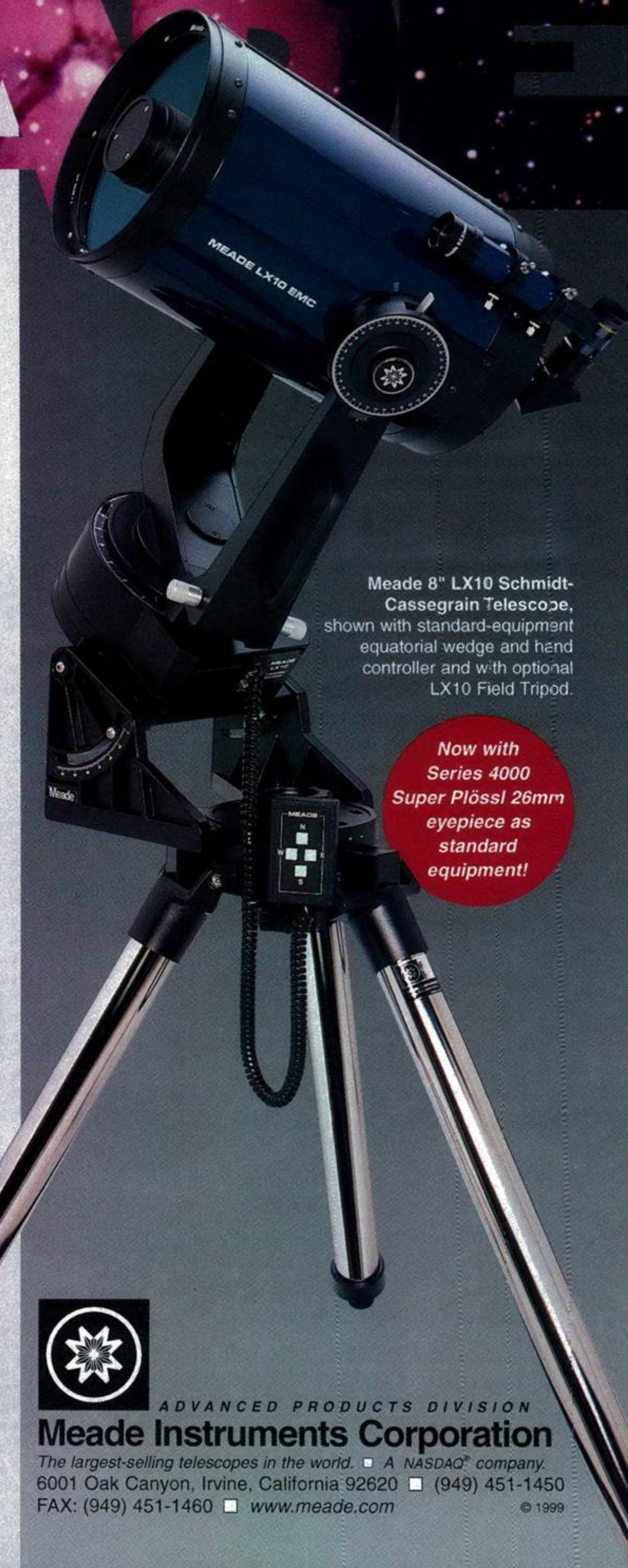

Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

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Model 102ACHR/500:
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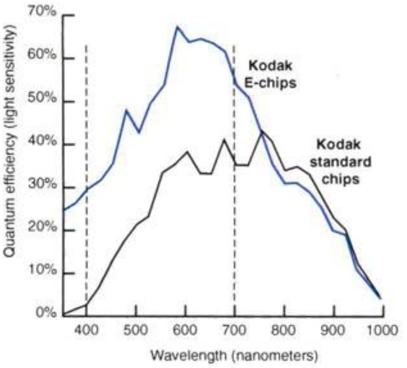
MEADE PICTOR XTE IMAGING SYSTEMS

How to cut all of your CCD exposure times in half!

New Meade Pictor 416XTE and 1616XTE imaging systems include the revolutionary Kodak E-Series of blue-sensitive CCD chips, permitting dramatically improved imager performance. With *twice* the overall light sensitivity and *four to ten times* the blue-light sensitivity of previous Kodak KAF-0400 and KAF-1600 chips *(see graph below)*, the E-chips incorporated into Meade XTE-series imagers nonetheless maintain the previous chips' low readout noise and dark current characteristics, as well as their high-resolution 9.0-micron-square pixel dimensions.

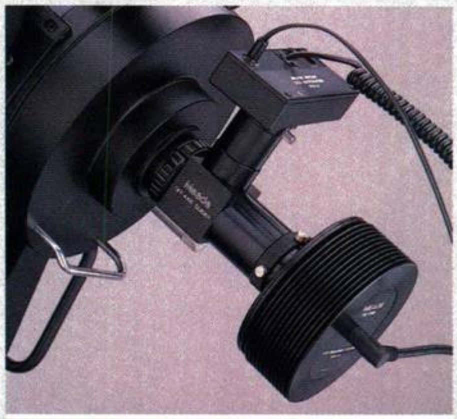
All Meade Pictor CCD models are fully compatible with the 32-bit operating platforms of Windows 95, 98, and NT, enabling fast, stable, smoothly-running program operation.

Use a Meade XTE-Series imager on your 6", or larger, telescope and obtain imaging results that match or exceed the photographic results of many observatory telescopes. And, notwithstanding the enormous data-collection power of Pictor 416XTE and 1616XTE imagers, each system's standard-equipment SCSI interface enables full-frame download to the host computer in *seconds,* permitting virtually real-time object acquisition, focusing, and centering. On-board programs include automatic exposure level, dark current exposure, and flat-field sequence, in addition to pixel binning.



Kodak E-chips used in Meade XTE imagers result in greatly increased light sensitivity. In this graph the region of visible wavelengths (400nm. to 700nm.) is indicated by dotted lines.

Meade Pictor 416XTE and 1616XTE models are a revelation of high-speed imaging performance on telescopes of all types and apertures. Applied to Meade LX200 Schmidt-Cassegrain telescopes, imager operation and performance are extended still further, with advanced features such as Autocentering, Autofocus, and Automosaicking.



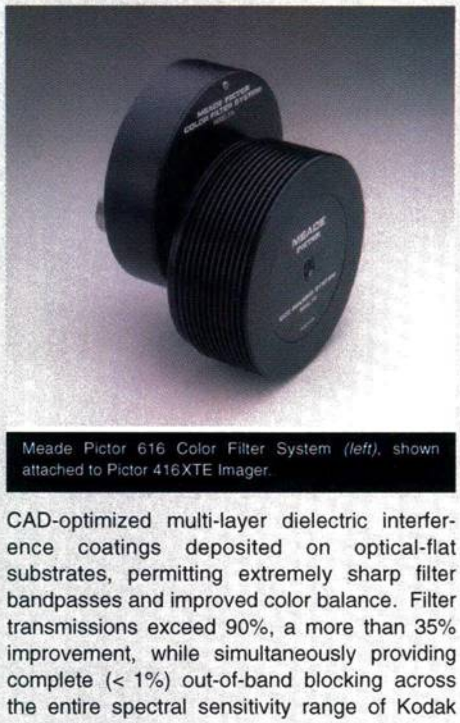
The Meade Pictor 416XTE imaging system, shown with #778 Off-Axis Guider, Image-Orientation Adapter, and Pictor 201XT Autoguider.

The Meade CCD Equipment System, provided at no additional charge with every Pictor 416XTE and 1616XTE, includes essentially all hardware and software required for advanced CCD imaging applications: **Pictor 201XT Autoguider,** for automatic guiding of the CCD camera during long-exposure imaging; **#778 Off-Axis Guider,** with adapters for use with either Schmidt-Cassegrain telescopes or with standard 1.25" eyepiece-holders; **CCD Image-Orientation Adapter** for precise orientation of the image on the CCD chip; and **Meade Epoch 2000ip Image Processing Software,** professional Windows-based image processing for the enhancement and analysis of CCD images — all packed in a foam-lined carrying case that provides for secure storage of the CCD camera and all items of the CCD Equipment System.

The Meade CCD Equipment System is included as standard-equipment with Pictor 416XTE and 1616XTE imagers.

Optimized Tricolor Imaging with the New Pictor 616 Color Filter System

Recent performance improvements in the Meade Pictor 616 Color Filter System are as remarkable and dramatic as advancements in Meade XTE imagers. The new tricolor filter set includes red, green, blue, and clear filters with CAD-optimized multi-layer dielectric interference coatings deposited on optical-flat substrates, permitting extremely sharp filter bandpasses and improved color balance. Filter transmissions exceed 90%, a more than 35% improvement, while simultaneously providing complete (< 1%) out-of-band blocking across the entire spectral sensitivity range of Kodak E-series CCD's.



Meade Pictor 616 Color Filter System *(left)*, shown attached to Pictor 416XTE Imager.

MEADE XTE IMAGING SYSTEMS

Pictor 416XTE (16-bit), with Meade CCD Equipment System	**$1995**
Pictor 1616XTE (16-bit) with Meade CCD Equipment System	**6495**
Pictor 616 Color Filter System, for use with Pictor 416XTE, 1616XTE	**695**

For complete information on Meade CCD imaging systems, write, call, or fax for your free copy of the 120-page Meade General Catalog.

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MEADE

STARFINDER™ EQUATORIAL NEWTONIANS

Meade® Starfinder 8" Equatorial with Motor Drive... *now only* ***$599!***

Complete with giant rack-and-pinion focuser for 1.25" and 2" eyepieces, 6 x 30mm viewfinder, Super Plössl 26mm eyepiece, and premium-grade Pyrex® optical system.

Precision, heavy-duty equatorial mount with DC-powered drive system for fully automatic tracking.

Shown with optional #2011 Magellan I Computer System.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System: For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries or from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 1.25" and 2" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 giant focuser.

MEADE
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I Telescope Computer System: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade Starfinder Equatorial 6", 8", or 10"	**$295.**
#2012: for Meade Starfinder Equatorial 16"	**295.**

MEADE
MAGELLAN II

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for Starfinder Equatorial 6", 8", 10"	**495.**
#2019: for Starfinder Equatorial 16"	**595.**

Packing & shipping in the 48 states: Magellan I – $15, Magellan II – $20.

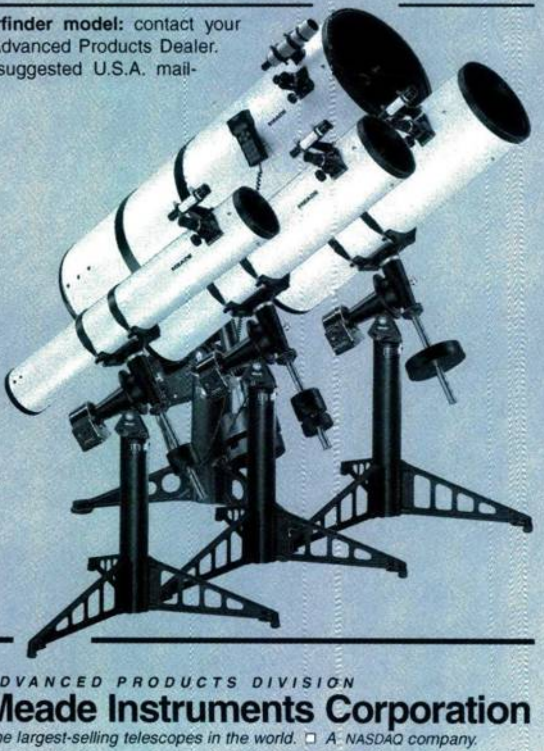
Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

Meade Starfinder Equatorial Telescopes

6" f/8	**$499**	**10" f/4.5**	**699**
8" f/6	**599**	**16" f/4.5**	**2695**

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

To Order any Starfinder model: contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.



New 120-page 2000 Meade General Catalog!

Write, call, or fax Meade Instruments for your free copy.

ADVANCED PRODUCTS DIVISION

Meade Instruments Corporation

The largest-selling telescopes in the world. ☐ A NASDAQ company.

6001 Oak Canyon, Irvine, California 92618 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

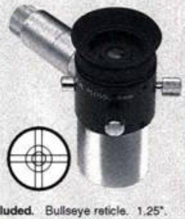
Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

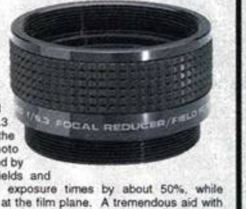
Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener



Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#911B
#910B
#908B

#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: *Permits use of wide-field 2" oculars.* Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

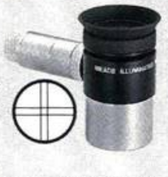
$79.95 (6.85)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

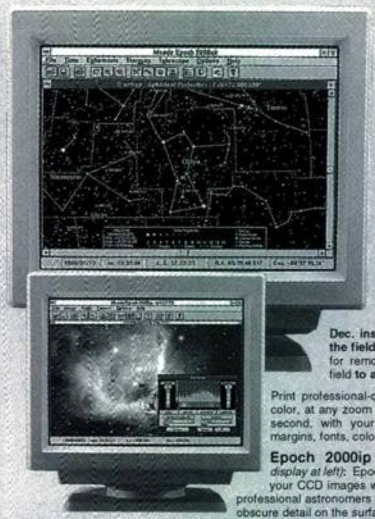
#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#644

#647

MEADE
FLIP-MIRROR SYSTEM



Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left):* Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$149**
EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM	**179**
LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk	**25**
EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95	**$199**

f/3.3 CCD FOCAL REDUCER

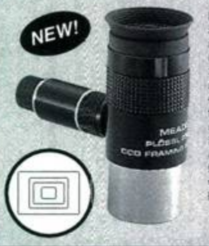
Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!



Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

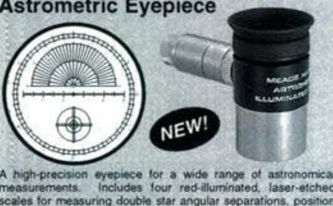
NEW!

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



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Black Water?

I was interested in the "DarkSky" website referenced in a sidebar to the Nebraska Star Party article (May 2000). Steve Albers designed that site to help find the darkest sites available. When I clicked on the big map for locations near the Tri-State Area eight miles off New York City, six choices were proposed — all in the Atlantic Ocean. Is someone suggesting I trade my Dobs for a diving suit? — *Jean-Dominique Turgis, Rutherford, New Jersey*

Not unless you're really good at treading water. The introduction to the DarkSky website states that anyone near large bodies of water needs to adjust the clicking position accordingly because the data cannot discriminate between land and water. Please try again, this time fudging your location a bit to find a dry site. — Astronomy *editors*

DMSP/NOAA/IDA

A nighttime satellite image of the U.S. illustrates the light pollution concerns facing stargazers.

Probability Unchanged

I would like to correct a misconception implicit in your Event Horizon headline "Near-Earth Asteroids Not That Big a Threat" (April 2000). The article correctly reports recent evidence that the number of near-Earth asteroids (NEAs) may be only half as great as previously thought. However, this does not change our estimate of the frequency of Earth/asteroid impacts, which is derived primarily by studying lunar lava plains (maria) impacts over the past 3 – 4 billion years. Therefore, the frequently cited estimate that — based on lunar cratering — Earth is struck approximately once per million years by a million-megaton-energy NEA is not altered by a lowered estimate of NEAs.

Rather, the impact hazard remains the same as before: Our most extreme example of a natural catastrophe has a very small probability but very large magnitude. The good news is that the NEA discovery rate is much higher than it was even a couple of years ago. So far we have discovered approximately one third of the NEAs greater than 1 km in diameter. Every new asteroid discovered and charted reduces our chances of being struck without warning by an undiscovered NEA. — *David Morrison, NASA Ames Research Center, Saratoga, California*

Absolutely Obsolete?

I read with amazement — and disgust — in your April 2000 issue that when NASA repaired the Hubble Space Telescope last year they installed an Intel 80486 DX2 computer. Why on earth NASA spent so much time and money putting such a hopelessly obsolete computer into its most important orbiting instrument is beyond comprehension. — *David Allen Hines, Kingston, Pennsylvania*

Many people are amazed with the fact that the new Hubble computer is essentially a 486 computer. What most people are not aware of is the rigorous design, engineering and testing involved in preparing a space-flight-ready component. All flight hardware (including the computer) must withstand the force and vibration of takeoff as well as the harsh environment of space — where temperatures fluctuate by 400° F.

Spacecraft and orbiting objects also encounter high-level radiation belts. A home computer could not withstand these conditions. The 486 computer installed on the STS-103 mission was test-flown on STS-95 to ensure that it would hold up. This new computer has six times more memory and is 20 times faster than Hubble's former computer. Sandia Laboratories, in cooperation with Intel Corporation, is currently working on developing a space-flight-ready Pentium. Production is still three to four years away. — Mindy Deyarmin, Hubble Space Telescope Outreach Specialist, Goddard Space Flight Center, Greenbelt, Maryland

Good Company

I'm an "entry level" serious amateur astronomer with a 6-inch Newtonian reflector and a new 4-inch refractor. When I flip to an *Astronomy* article on Joe Smith, with his $10,000 scope, or John Doe with his enclosed, custom-built observatory/shelter, replete with state-of-the-art CCD camera(s), computer equipment, etc., it makes me wonder: Just what is the demographic breakdown among your readership regarding age, gender, marital status, income, price of instrument owned, and how much time is spent observing

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per week? — *J. R. McGlown, Jr., Fort Rucker, Alabama*

The typical Astronomy *reader owns a telescope (probably a Newtonian reflector model) and is a married male in his late 40s with an average annual income of nearly $80,000. He spends between $500 – $1,000 annually on his hobby, to which he has devoted about nine hours per month for the last 14 years. Fifty percent of* Astronomy*'s readers keep their magazines indefinitely. — Astronomy* editors

Rising Stargazers

I took my family to view the Perseid meteor shower from a friend's chateau 20 kilometers from Toulouse, France. The bright moon washed out all but the brightest meteors. Nevertheless, we persevered. To save our aching necks, we lay down in a line on the path leading up to the chateau from the road. Our French hosts' dog came and sniffed us, took no further action, and returned to his chateau a bit confused. However, he was not as confused as our French hosts were upon their

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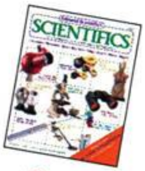

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return as the headlights of their car picked out four bodies rising from the path! Their faint grasp of English and my lack of French never really explained our behavior. — *L. A. Britton, Bristol, England*

Corrections

Brian Lula was the photographer of the Horsehead Nebula that appeared on page 89 of the April 2000 issue.

In the May 2000 issue, we incorrectly identified the International Dark Sky Association's website as "Steve Albert's DarkSky" website. The correct spelling of Steve's last name is Albers. And look for the IDA's website at www.darksky.org/~ida/darksky/. ■

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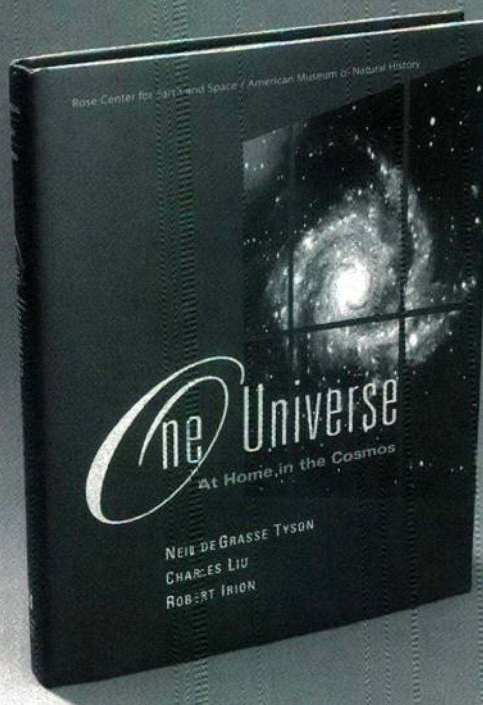

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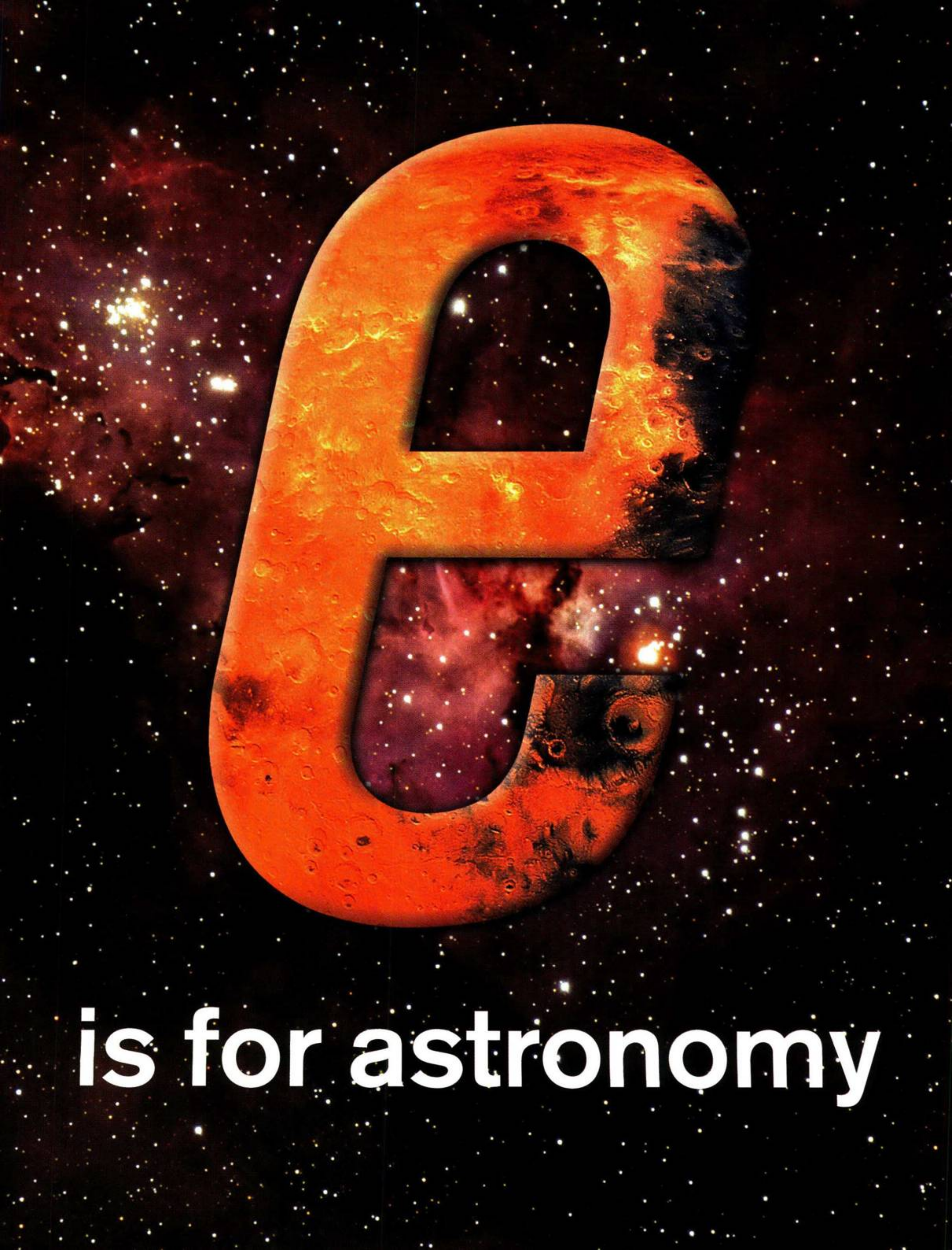
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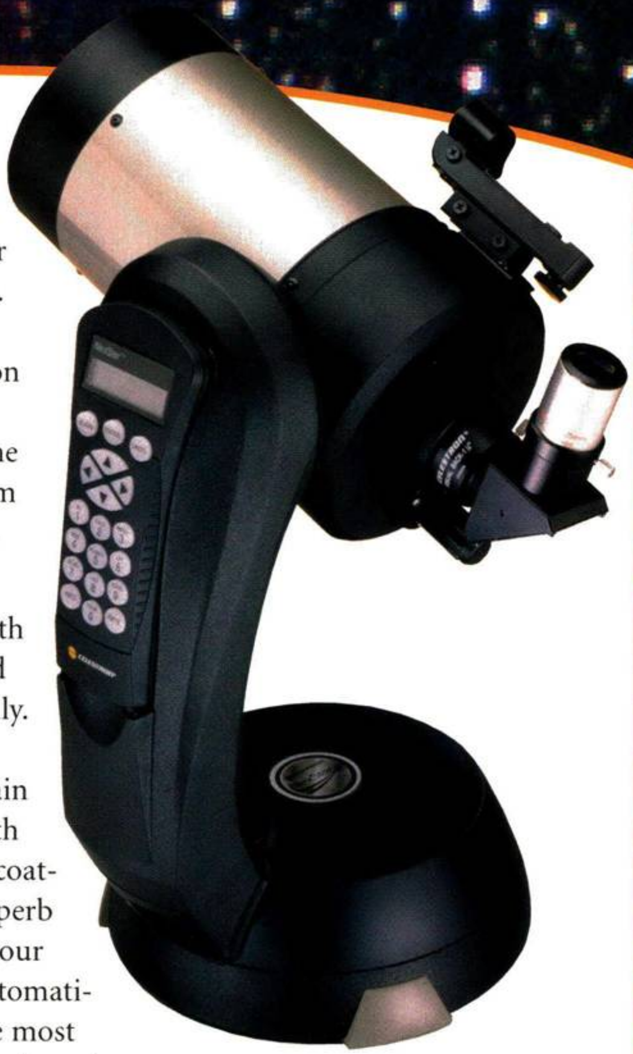

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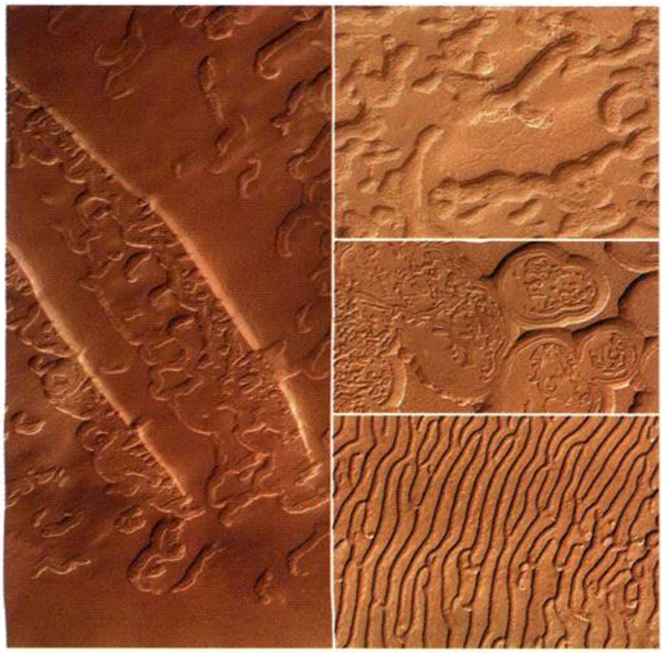
MARS GLOBAL SURVEYOR

Martian Poles a World Apart

▶ Although Wisconsin proudly proclaims itself the Dairy State, Mars is putting in a bid to be known as the Dairy Planet. No, no one has seen herds of cows wandering the not-so-fertile martian plains. But the highest-resolution images ever returned of the planet's polar caps show that they bear an uncanny resemblance to cheese.

What has planetary scientists most excited is that the cheese of the north polar cap differs from that of the south. The north polar cap has a relatively flat surface covered with pits, cracks, small bumps, and knobs that resemble cottage cheese. The south polar cap, on the other hand, has larger pits, troughs, and flat mesas that give it a holey, Swiss-cheese appearance.

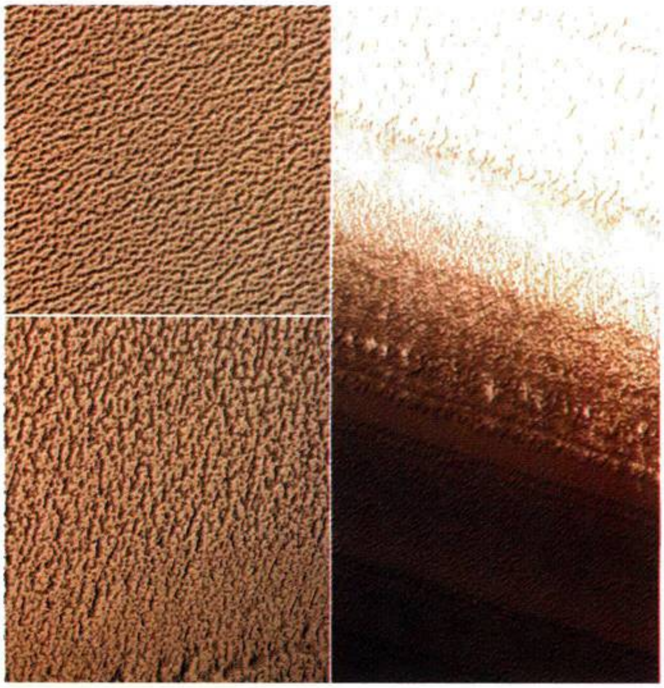


Global Surveyor reveals the varied terrain of Mars's south polar cap. Older, deeper layers seem to show more pits (left). Erosion creates the debris surrounding mesas (right, top). Circular collapse features give the cap a Swiss-cheese appearance (right, middle). Long troughs have no counterparts anywhere on Mars (right, bottom). NASA/JPL/MSSS

The polar cap differences are more than skin deep. The north residual cap — the part that survives the relatively warm and sunny martian summer — grades quite smoothly into layered deposits at the cap's edge. Not so in the south. There the residual cap appears as a distinct geologic unit that shows evidence of erosion or collapse affecting at least four layers, each several feet (about 2 meters) thick.

"The unusual shapes of the landforms on the north and south polar caps suggest that these regions have had different climates and histories for thousands or perhaps even millions of years," says Peter Thomas of Cornell University, a member of the Mars Global Surveyor imaging team and lead author of the paper that appeared in the March 9 issue of *Nature*. The team's discoveries come thanks to new images that show details as small as a few feet across, some 30 to 50 times sharper than most previous images.

Imaging team member Andrew Ingersoll of the California Institute of Technology thinks that the new images may also help planetary scientists decide what the south polar cap is made of. The north residual cap consists of water ice, a fact that has been known since the Mariner 9 and Viking space missions of the 1970s.



Pits in the north polar cap make it look more like cottage cheese or a kitchen sponge (left, top and bottom). The surface of this cap (right, in white) grades into the layered terrain. NASA/JPL/MSSS

The south residual cap seems to be frozen carbon dioxide, or dry ice, but it's not clear whether the ice forms a veneer perhaps 10 feet (a few meters) thick or a solid block that extends down a mile or two (2 to 3 km). If both caps turn out to be largely water ice, Ingersoll says, the mystery would be why so little carbon dioxide exists on Mars.

"These polar images demonstrate again that understanding Mars's complicated history requires studying many areas in detail," adds Thomas. "Just as understanding Earth does." — RICHARD TALCOTT

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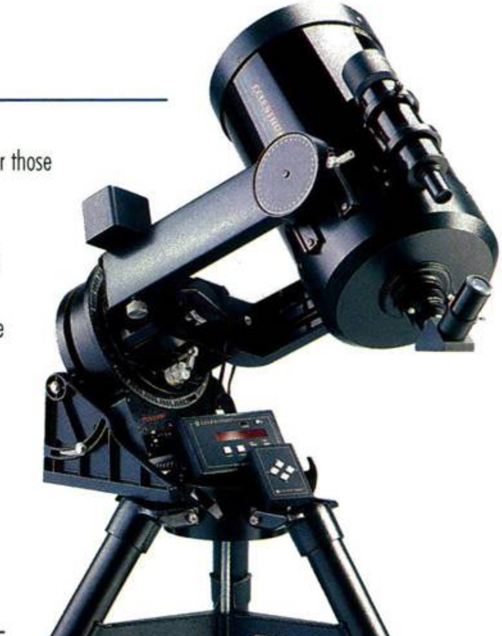

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CGRO MISSION

Compton at the End of the Road

It's been orbiting Earth for nine nearly flawless years. It remains one of NASA's most productive spacecraft. It helped change the way we think about the universe. But it has to come down.

The end is nigh for the Compton Gamma-Ray Observatory. Last December one of the spacecraft's three gyroscopes failed, and NASA was forced to make a decision. Although Compton needs only two gyros to keep itself properly oriented — and has continued operating normally with two — the same couldn't be guaranteed if another one went. (NASA estimated the chances of that at 10 percent during the next three years.) That created a slight but real risk that the observatory would one day spin out of control and crash back to Earth.

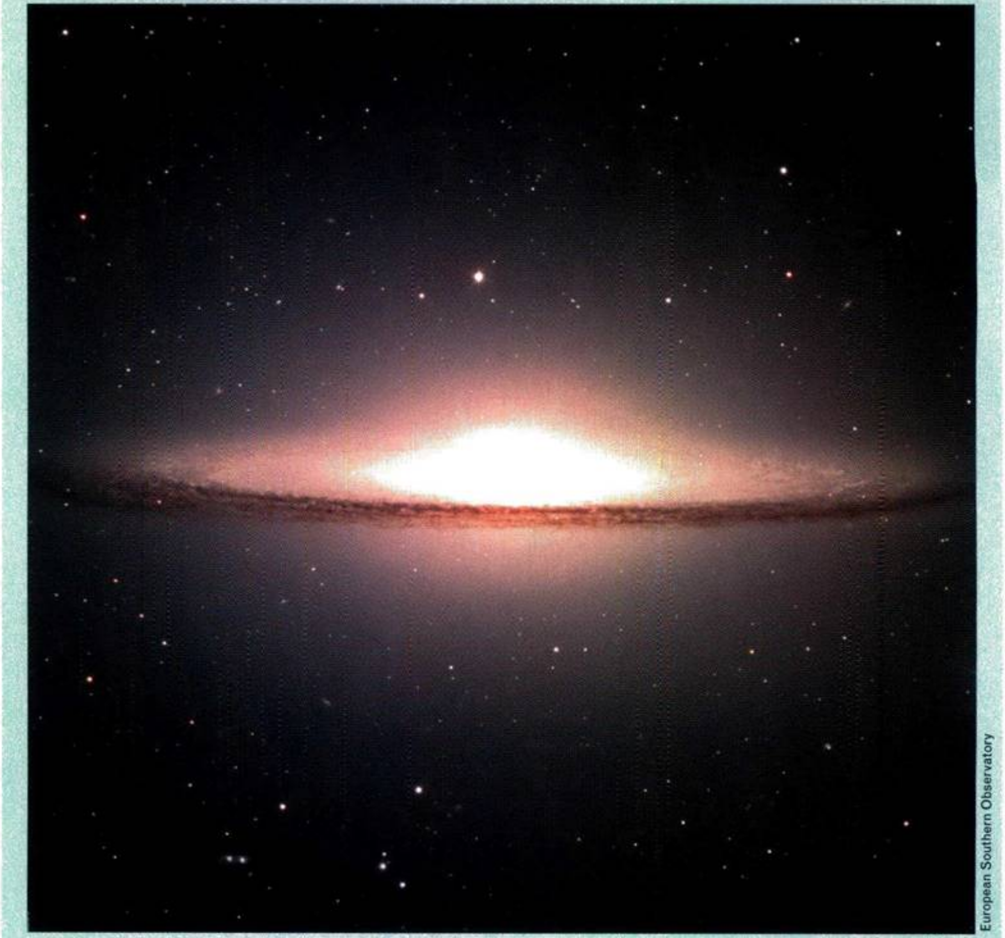
"NASA must have a controlled reentry to direct Compton toward an uninhabited area in the Pacific Ocean," says Ed Weiler, Associate Administrator for NASA's Office of Space Science. Despite the observatory's continuing productivity, Weiler asks, "How many scientific papers are worth an increased risk to human life?"

NASA had actually decided Compton's fate even before it was launched from the space shuttle in April 1991. The main worry stems from the spacecraft's size — at 17 tons it was the heaviest astronomical payload ever lifted into space. Most of the observatory will burn up during reentry, but NASA estimates that 30 to 40 fragments will survive, ranging from the size of a bolt up to pieces weighing a ton.

As *Astronomy* went to press, NASA expected to bring Compton down in early June. The plan calls for shutting down the scientific instruments on May 26. Five days later, flight controllers will fire the spacecraft's thrusters in the direction opposite to its orbital motion, slowing the spacecraft and causing it to dip into the atmosphere. Three subsequent burns will slow Compton enough for it to fall out of the sky right where NASA wants — over the eastern Pacific Ocean. The space agency expects debris to scatter across an area roughly 15 miles wide by 1,000 miles long (25 km by 1550 km) located some 2,500 miles (4,000 km) southeast of Hawaii.

During nine years in space — nearly twice its intended five-year lifespan — Compton explored the violent world of gamma-ray

VERY LARGE TELESCOPE



European Southern Observatory

LOOKING LIKE A MEXICAN HAT, the Sombrero Galaxy (M104) in Virgo ranks among the brightest and most massive galaxies in the sky. The spiral tilts just 6° to our line of sight, and the thick dust that clogs the plane of the galaxy forms the distinctive hat brim. This portrait, taken with one of the four 8-meter telescopes that compose the European Southern Observatory's Very Large Telescope in Chile, shows details as small as 170 light-years across. Note the galaxy's large population of globular clusters and the many faint background galaxies that shine through its outer regions. Located some 50 million light-years from Earth in the Virgo Cluster, the Sombrero holds an exalted position in the history of astronomy. It was among the first galaxies to have its redshift — used to help prove that the universe is expanding — and rotation rate measured in the 1910s.

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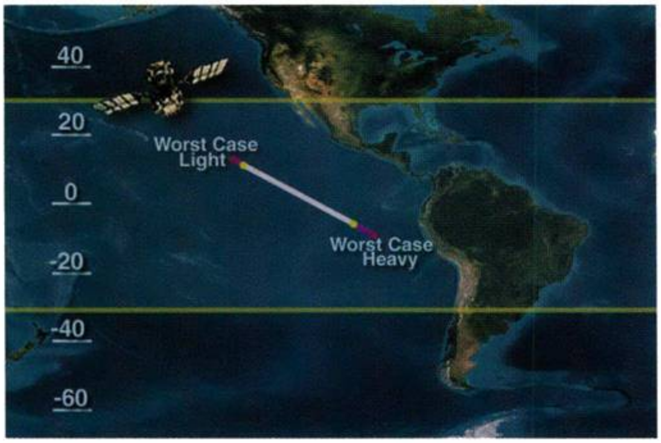

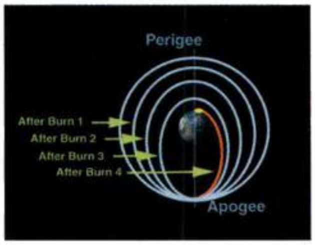

The Compton Gamma-Ray Observatory should come down in early June over the eastern Pacific Ocean (above). NASA plans a series of four thruster firings, or burns, to slow the spacecraft enough so it plunges into the atmosphere (right). NASA/GSFC

astronomy. It discovered ten times more gamma-ray sources than previously known, an antimatter fountain in the center of our galaxy, and jets of matter streaming away from black holes at a large fraction of the speed of light.

But it will be most remembered for showing that enigmatic gamma-ray bursts are the biggest explosions in the universe. Before Compton's launch, most astronomers thought these intense bursts came from our own galaxy. Compton showed that they appeared in every direction and must therefore originate in the distant universe.

NASA plans to follow up Compton's success with two more gamma-ray missions: Swift, which will observe gamma-ray bursts and is set for launch in 2003, and the Gamma-ray Large Area Space Telescope (GLAST), which will concentrate on high-energy gamma-ray sources after its planned 2005 launch. — R. T.

COMET SCIENCE

Hyakutake's Giant Tail

▶ In the spring of 1996, people around the world watched in amazement as Comet Hyakutake's tail stretched more than halfway across the sky. But it turns out that the tail was a lot longer than it appeared from here on Earth.

Recently analyzed data from the joint NASA/European Space Agency solar probe Ulysses shows that most of Hyakutake's tail was invisible, meaning that comet tails may typically extend hundreds of millions of miles longer than scientists had previously thought.

Two teams of scientists independently made the discovery while sifting through Ulysses data taken on May 1, 1996. The team in charge of the spacecraft's solar wind ion composition spectrometer found that the solar wind suddenly and unexpectedly became hotter and calmer, while the number of charged particles skyrocketed by a thousandfold. The solar wind is a stream of charged particles from the sun that at the time was blowing by Ulysses at more than 450 miles (730 km) per second.

The other team, which studies data from Ulysses's magnetometer, found that the magnetic field lines of the solar wind suddenly changed direction. The distorted readings from both instruments occurred simultaneously and lasted for just a few hours.

"Although the change in the magnetic field was typical of what we would expect from a comet tail, there was no known comet in the area, so we initially discounted the event," says Geraint Jones of Imperial College in London, England, who led the magnetometer team's study of the episode. "When we looked again at the instrument readings we were convinced it was a comet, so we decided to look farther out into space and realized Ulysses had crossed the tail of Comet Hyakutake, which was then far away in another part of the solar system."

If measured along the curvature of the comet's tail, Ulysses was more than 350 million miles (570 million km) from the "dirty-snowball" nucleus of Hyakutake, meaning the tail's length must have been at least 3.8 times the Earth-sun distance.

"The discovery was made quite by accident, a bit like finding a needle in a haystack when you weren't even looking for the needle in the first place," says spectrometer team leader George Gloeckler of the University of Maryland.

Magnetometer team member Edward Smith of the Jet Propulsion Laboratory adds, "The odds that Ulysses's flight path would intersect the comet tail were probably less likely than someone breaking the bank at Monte Carlo."

Because comet tails are probably much longer than

Comet Hyakutake's tail may have looked long when it passed by Earth in March 1996, but measurements made by the Ulysses spacecraft proved it — showing that the tail stretched at least 350 million miles.

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previously thought, future spacecraft should have a much easier time sampling comet material. "We now believe that with a much more sensitive version of the ion composition spectrometer found on Ulysses, a spacecraft could travel through regions of the solar system picking up ions from the many invisible comet tails that probably crisscross our solar system," says Gloeckler.

Both Ulysses teams reported their findings in the April 6 issue of *Nature*.
— ROBERT NAEYE

SATELLITE NETWORK

Say Goodbye to Iridium

► Unless a last-minute buyer can be found, the entire constellation of 66 Iridium satellites will burn up in the atmosphere over the next two to three years. While Iridium investors are singing the blues over the loss of the $5-billion satellite network, radio astronomers will be able to observe some of their favorite frequencies in relative peace and quiet. (Some skywatchers may mourn the network's demise, however — viewing bright "Iridium flares," which were generated when sunlight hit a satellite's solar panels at just the right angle, had proved to be a popular pastime.)

Iridium's radio downlinks often drowned out much weaker natural radio sources in deep space. "The Very Large Array will once again be able to observe the 1612 megahertz line," says National Radio Astronomy Observatory spokesman David Finley, speaking of the array of 27 radio telescopes located outside Socorro, New Mexico. The 1612 megahertz line of the hydroxyl molecule (OH) is crucial for the study of star-forming regions and other astronomical sources.

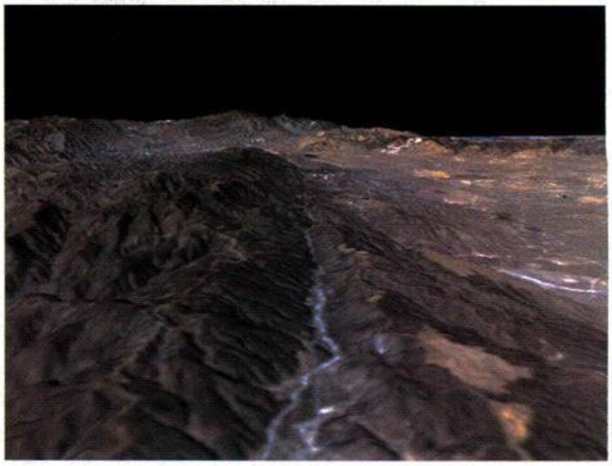
The Iridium satellites were to provide a global telephone communications network. But the company, which worked in partnership with Motorola, was victimized by a rapidly changing market in ground-based wireless telephone service. Iridium's phones were heavier and more expensive than standard cellular phones.

In addition, the phones often would not work indoors and telephone calls cost as much as $7 per minute. With minimal consumer interest — despite the system's global coverage that reached into remote areas — there was little revenue to offset the enormous investment. At the time Iridium cut off service to its customers on March 17, the company had only 55,000 subscribers.

On that same day, the United States Bankruptcy Court ordered Iridium to liquidate its corporate assets. Under current plans, all 66 satellites will be maneuvered to reenter Earth's atmosphere and burn up over the Pacific Ocean, taking advantage of the same wide-open waters that NASA will be using when it brings down the Compton Gamma-Ray Observatory in June. Although several organizations have expressed interest in buying the satellites, as *Astronomy* went to press, it appeared unlikely that a suitable buyer would be found.

Radio astronomers realize that their victory could be short-lived. As more and more Earth-orbiting satellites are launched, and more and more radio stations go on air, the din of artificial sources will swamp weak signals from astronomical sources. "We would like more of a formal protection than having to rely on the vagaries of the business world," says Finley. — R. N.

SHUTTLE RADAR


NASA/JPL/NIMA

THE SAN ANDREAS FAULT in California runs straight down the middle of this perspective view created from data returned by NASA's Shuttle Radar Topography Mission this past February. This segment of the fault lies west of Palmdale, California, about 60 miles (100 km) northwest of Los Angeles. The fault is the active boundary between the North American plate, which lies to the right of the fault and is moving toward the viewer, and the Pacific plate, which lies to the left and is moving away. (Also note the San Gabriel Mountains on the left of the image and the Tehachapi Mountains at the upper right.)

The mission used two antennae — one in the shuttle Endeavour's payload bay and the other mounted at the end of a 200-foot-long (60-meter) mast — to get slightly different views of the same area. The radar created a staggering 270 megabytes of digital data every second, which was stored on special tapes using high-speed recorders. From this information, scientists will be able to generate 3-D topographic maps of approximately 80 percent of Earth's land mass stretching from the southern tip of Greenland to the Antarctic Circle.

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Still, while this is clearly the main event at the Rose Center for Earth and Space, it is only part of the show. The Big Bang Theater, which occupies the bottom half of the sphere, presents a multisensory re-creation of the explosive first moments of the universe. And the Hall of the Universe, below the sphere, has a minitheater that shows a trip inside a black hole, a 12-foot-wide high-definition screen that broadcasts up-to-the-minute astronomy news, and dozens of touch screens with hundreds of images and thousands of factoids.

In fact, there are so many layers of information that some critics have called it overwhelming, complaining that their heads hurt as they leave from thinking too hard. And, they say, the exhibits are too sophisticated for small children. But, like the universe, this huge collection requires more than one visit for a real appreciation.

And if little kids are not amply amused by the Willamette Meteorite, a fifteen-and-one-half-ton piece of ancient cosmic debris on the first floor, the world-famous Hall of Dinosaurs can be found upstairs, through the Hall of Planet Earth — where giant "smokers" from the ocean floor and a rare ice core from Greenland also await. Parents certainly have no need to worry.

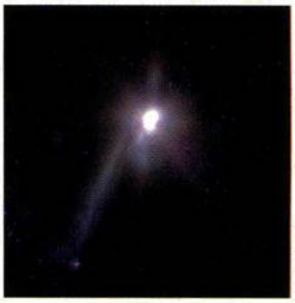
— Beth Livermore

The new Hayden Planetarium in New York lies inside the 87-foot-wide sphere in the middle of the Rose Center for Earth and Space.

© D. Finnin/AMNH

The "Protoplanet" That Isn't

Astronomer Susan Terebey of the Extrasolar Research Corp. created a big stir in 1998 when she announced the discovery of a possible protoplanet in images taken with the Hubble Space Telescope. If true, it would have been the first planet outside the solar system to have been imaged. The object, called TMR–1C and located 450 light-years away in Taurus, appeared as a bright dot at the end of a long streamer of dust. Other astronomers pointed out that the object could be a distant star dimmed by dust, and now Terebey agrees. Using the 10-meter Keck Telescope, she found the object to be hotter than 4400° Fahrenheit (2700 kelvins), much hotter than a protoplanet. Reporting in the May *Astronomical Journal*, she says, "The new data do not lend weight to the protoplanet interpretation and are consistent with its being a background star."



The faint object at lower left turns out to be a background star and not a planet.

NASA/STScI

New Champion at Edge of Universe

Astronomers of the Sloan Digital Sky Survey (SDSS) have pushed the boundaries of the universe once again, discovering a quasar that probably formed less than a billion years after the Big Bang. Quasars — brilliant galactic centers powered by supermassive black holes — shine so brightly that they can be seen clear across the cosmos. A spectrum of this quasar showed it to have a redshift of 5.8, meaning that the universe's expansion has shifted its light to the red by 580 percent. In the past 18 months, SDSS has more than doubled the number of known quasars with redshifts greater than 4.5. And Donald York of the University of Chicago, one of the initiators of SDSS, says: "You haven't seen anything yet. By the time the Sloan Survey is done, it will rewrite the book on quasars and the early evolution of galaxies."

Green Bank Telescope Nearly Completed

The last of 2,004 aluminum surface panels was installed in the massive Green Bank Telescope (GBT) early this spring. When completed, the GBT will be the largest fully steerable radio telescope in the world. The telescope, located at the National Radio Astronomy Observatory site in Green Bank, West Virginia, rises 485 feet above the ground, weighs 16 million pounds, and has a 2-acre collecting area. It will study the formation of galaxies in the early universe, the chemical composition of the dust and gas in ours and other galaxies, and the birth processes of stars. If all goes according to plan, the telescope will become operational in early 2001.

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RED PLANET RENAIS

Recent discoveries paint Mars as an active planet with erupting volcanoes and underground rivers.

by William K. Hartmann

The one constant in life is change. Few human endeavors support this adage better than does science, where new observations and theories continually force scientists to modify their thinking. Yet despite this seemingly constant change, rarely does our knowledge of a subject come full circle.

That's precisely what makes the latest findings about Mars so extraordinary. Just five years ago, astronomers viewed the Red Planet as an old, essentially dead world. Recent discoveries made by the Mars Global Surveyor spacecraft and gleaned from martian meteorites now suggest a world where active volcanoes and underground rivers of liquid water may exist today. In many ways, this emerging view bears a closer resemblance

Complex geological processes formed Coprates Chasma, part of the giant Valles Marineris system of canyons. NASA/JPL/MSSS

SANCE

to the Mars envisioned 200 years ago than the one planetary scientists saw in the mid-1990s.

Our story begins around 1800, when William Herschel and other observers pointed large telescopes at Mars. They saw clouds, polar ice fields, and dark markings that could be construed as oceans, all giving the impression that Mars was much like Earth. These observations led to the hypothesis of the plurality of worlds — that other planets were Earthlike. Mars presumably had an active meteorological and geological environment, like our own.

By 1900, Percival Lowell correctly pointed out that a small planet like Mars would lose its internal heat and atmosphere faster than a large one like Earth, and he pictured Mars as a dying, drying planet. Perhaps it once had an Earthlike environment, but it was running down. Oceans were soon ruled out, and the martian air was proved to be very thin. In 1965 humanity's view of Mars reached its dismal nadir when the first successful Mars probe, Mariner 4, zipped past Mars and revealed no mountains, seas, lakes, canyons, or rivers, but rather impact craters like those on the moon. In an overreaction, scientists concluded that Mars was even more dead than had been thought — a moonlike world where only the occasional asteroid impact disturbed the planet's endless sleep.

This gloomy picture began to change in the 1970s, when Mariner 9 and two Viking spacecraft arrived at Mars. They revealed dry riverbeds, volcanic mountains, and sparsely cratered plains with lava flows. Clearly the planet had not been dead or passive but had experienced volcanic eruptions and flowing water that carved river channels winding hundreds of miles across its surface. Nonetheless, scientists agreed that the eruptions and river flows must have been confined to a primordial active period, perhaps 4 billion years ago, when Mars still had a hot interior and thick atmosphere.

The questions to ponder were, when did this active period end? What were the most recent lava eruptions or flows of liquid water? A widely quoted paper of the 1970s, by the German-American team of Gerhard Neukum and Donald Wise, studied the age relationships and the accumulated number of asteroid impact craters and concluded that all volcanism had stopped by 2.5 billion years ago. This picture was what we might call the "Old Age Mars," with all activity ending in the first half or third of martian history. (For comparison, on the active Earth, the Atlantic Ocean basin is only about 70 million years old, the Gulf of California only a few million years old, and the San Andreas fault still carries Los Angeles to the north and west.)

The view of martian history continued to evolve in the 1980s. Neukum, working with K. Hiller, published a new analysis that concluded most martian activity was still old but the tail end of volcanism extended into more recent times. Similarly, a NASA-sponsored study of basaltic volcanism in the solar system took a fresh look at martian crater accumulation and concluded that many lava plains were between 1 billion and 2 billion years old with the famous volcanic cones, such as Olympus Mons, as young as a few hundred million years.

Soon after, scientists recognized that a handful of meteorites on Earth had come from Mars. The first good dating of these rocks identified one group as lavas that solidified 1.3 billion years ago. The data seemed consistent, giving a picture that we might call the "Middle Age Mars." In this view, most of the river channels formed early in Mars's history but much of the active geology continued into the middle third of the planet's life and the rare, last gasps of volcanic activity persisted into the last few hundred million years.

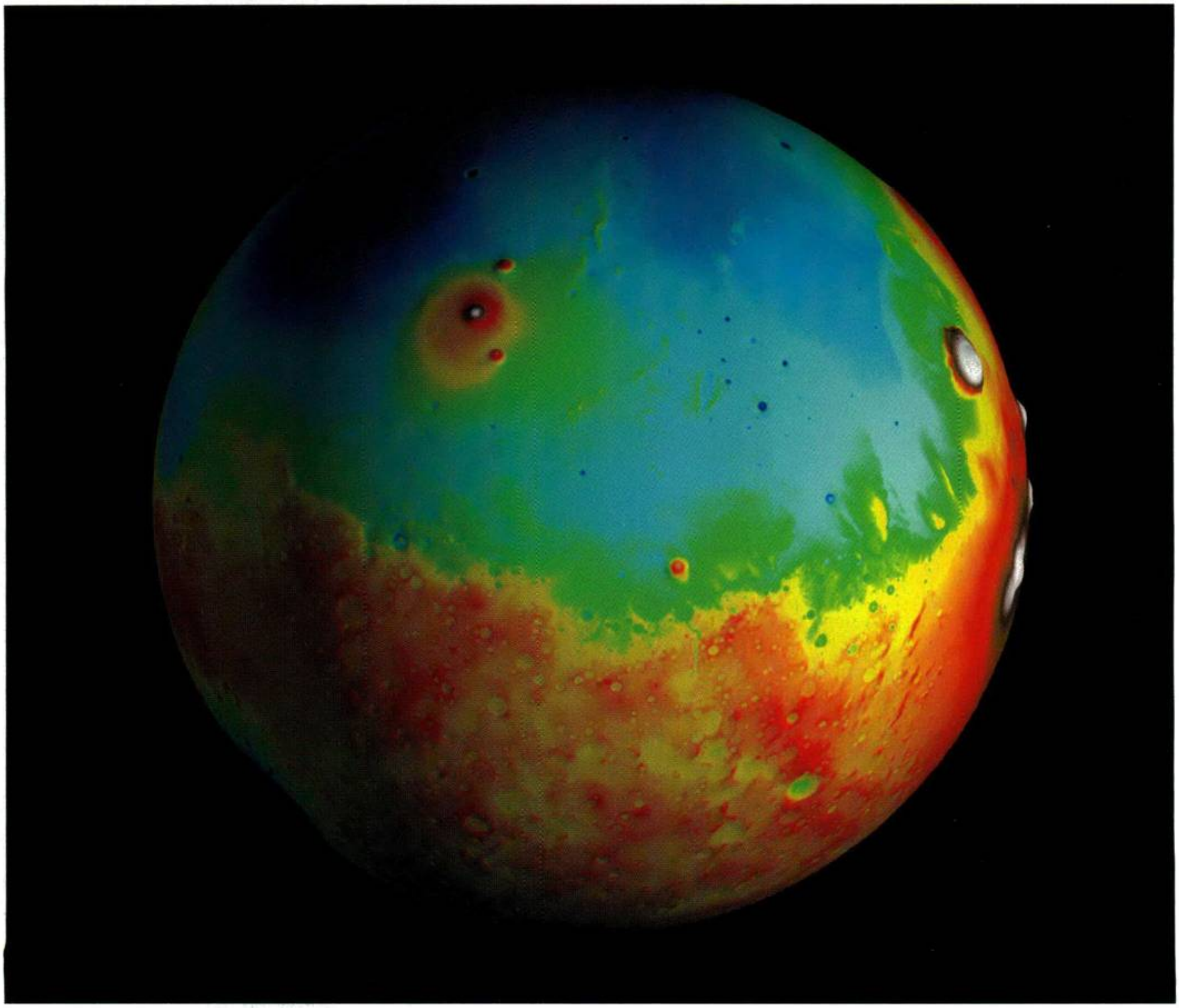
The Middle Age Mars endured into the 1990s and formed the basis for most of the planning that went into the current round of Mars missions. Yet this picture is now being overturned by recent developments. New dating of martian meteorites and results from the current Mars Global Surveyor mission portray a "Youthful Mars" — a planet with ongoing volcanic activity and flowing water.

ROCKS FROM MARS

The martian meteorites, now numbering just over a dozen, can be divided into several groups. One group crystallized 4.5 billion years ago as the planet was forming, was subjected to some sort of shock (probably from an impact) around 4 billion years ago, and then was blasted off Mars by an impact about 14 million years ago. A second group consists of basaltic lava that erupted and solidified 1.3 billion years ago and was blasted off Mars some 11 million years ago.

The third group plays a key part in the current revolution in martian thinking. These meteorites seem to have solidified only 100 million to 700 million years ago. Many researchers initially thought that these ages were too young to reflect geological activity on Mars and suggested instead that the ages might reflect when the rocks were shocked or melted by a major impact. However, modern research on the

This recently identified martian meteorite is only about 100 million years old. Ron Baalke



mineralogy of these rocks has convinced most scientists that they really did crystallize from molten material 100 million to 700 million years ago. The groupings of rock ages probably represent three or four different impact sites on Mars.

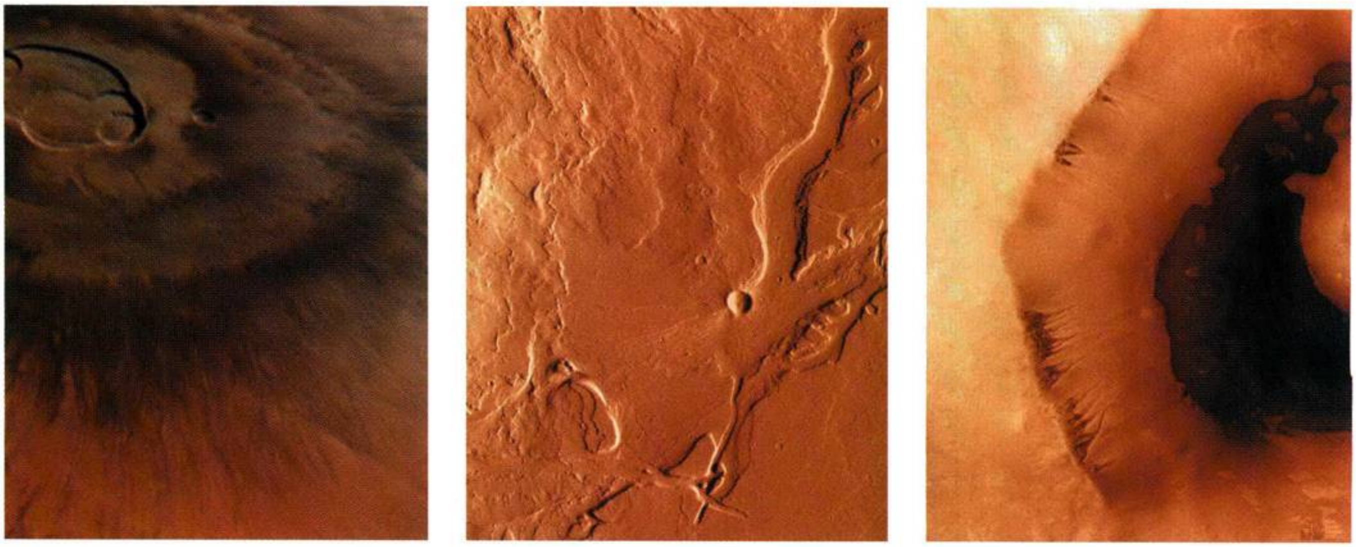
So the first revolutionary fact is that geologically young rocks apparently are not rare on Mars. After all, many of the martian meteorites formed from molten magmas only a few hundred million years ago, and two of the impact sites launched rocks no older than 1.3 billion years of age. This means rocks were forming not just in the first or second third of martian history, but within the last ten percent of the planet's lifetime.

The second revolutionary fact is that liquid water apparently flowed on the surface of Mars and percolated into these rocks in the same general time span. For example, University of Arizona researcher Tim Swindle and his colleagues found that rustlike minerals caused by weathering formed inside cracks in one of the 1.3-billion-year-old basalts only about 650 million years ago, with an uncertainty of around 20 million years. This finding is independent of the other young ages.

Furthermore, many of the martian meteorites in the 100-million to 700-million-year group have rustlike minerals, carbonate deposits, or clay minerals inside them that formed by the action of liquid water. This proves that at least some locations on Mars have been exposed to liquid water, concentrated water vapor, or both within the last few hundred million years — an idea few planetary scientists would have accepted even five years ago.

A third revolutionary fact comes from the Mars Global Surveyor (MGS) mission. Some members of the MGS research teams like to joke that MGS is the Stealth Mission to Mars. The spacecraft arrived at Mars shortly after the famous Mars Pathfinder landing of July 4, 1997, and that dramatic mission, with its airbag touchdown and Sojourner rover, completely overshadowed the MGS orbiter in the media. Two years later, with MGS well into its mapping mission and turning out thousands of detailed images of the Red Planet, the failure of both Mars Climate Orbiter and Mars Polar Lander again deflected attention away from MGS's new data.

The MGS laser altimeter revealed Mars's topography, with the highest terrain shown as white and progressively lower areas by red, yellow, green, and blue. Water once flowed from the southern highlands to the northern lowlands. NASA/GSFC/MOLA Science Team



The volcano Olympus Mons (left) rises 16 miles above the martian surface. Some lava flows near it (center) are only a few hundred million years old. Even more recently, liquid water apparently seeped out of a martian crater wall (right), eroded a gully, and left dark deposits on the floor. NASA/JPL/MSSS

Among the photos, MGS team members such as Alfred McEwen in Arizona and Mike Malin and Ken Edgett in California have recognized extremely fresh-looking lava flows in the Elysium Planitia region, with rugged lava textures barely modified by dust deposits or subsequent impact craters. My own work on the MGS team was to count the number of impact craters on these and other surfaces. To our surprise, we found that the youngest lava flows have less than one percent as many craters as the lunar lava plains where Apollo astronauts walked.

Through the combined work of researchers such as Boris Ivanov in Russia, Alessandro Morbidelli and Paolo Farinella in Italy, and Bill Bottke and Luke Dones in the United States, we now know that impact craters of the same size formed on Mars at roughly the same rate as on the moon. This means that the young flows on Mars can't be more than about one percent of the age of the lunar lava plains, or perhaps 20 million to 60 million years. Some flows in the area may be even younger. We have also estimated ages of less than 100 million years on the youngest flows on Olympus Mons and ages around 200 million to 400 million years on broad lava plains of Tharsis and Amazonis Planitia.

This suggests that the youngest activity on Mars has extended to the last one percent of the planet's history. If martian volcanoes have been active through 99 percent of martian history, there's no reason to suppose that they all shut down just before we humans arrived. In other words, the new MGS data strongly argue that volcanism on Mars has continued into modern times and that the volcanoes will erupt again in the future. Whether this might be in the 21st century or a million years from now, we can't say.

UNDERGROUND RIVERS

The fourth revolutionary fact also comes from MGS. The spacecraft found several examples showing that underground liquid water likewise exists in modern geologic time and perhaps could be found by astronauts. MGS researcher Michael Carr of the U.S. Geological Survey has pointed out that the headward or source-region ends of some martian river channels are fairly abrupt, without any smaller runoff channels to feed them. This suggests that the water supplying those channels did not come from the surface, as would be expected for runoff from rain or snow, but from underground.

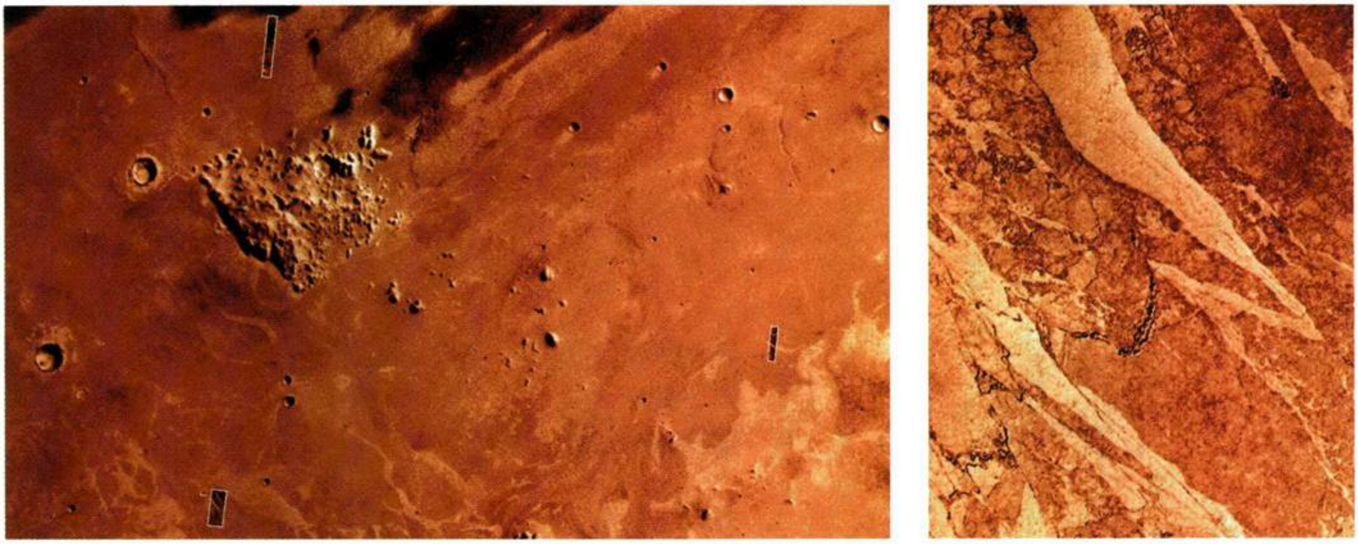
More provocatively, Carr has found rows of collapsed pits extending beyond the source of the channel into the martian desert. In other words, the channel extends underground in the upstream direction, and the ground collapsed here and there into the underground feeder. This type of collapse into underground cavities, created as water dissolves or erodes underground rock, is common on Earth in so-called karst terrain, where limestone caverns are found.

The presence of possible springlike seeps in crater walls or cliffsides offers another line of evidence for underground water sources. Early in the MGS mission, imaging team leader Mike Malin released an image of a disturbance halfway down a crater wall. Below this is a narrow gully that runs down into the floor, where some dark deposits can be seen.

This implies that underground liquid water flowed out of the wall and then ran down, eroding a gully. French-American researcher Nathalie Cabrol has pointed to other examples and emphasizes that some craters may have contained ponds or lakes. All these features look surprisingly young, having few or no impact craters on them. Also, there is widespread evidence for downslope erosion and deposition of cliff face materials continuing to this day, so if these 100- to 200-foot-wide features were old, they would have been blanketed and hidden long ago.

Combining all this evidence — some martian meteorites were exposed to water within the last several hundred million years, the water flow most likely did not stop just before humans arrived, and we see places where water seems to be seeping out from underground in more recent geologic time — provides a compelling argument that, at least in a few regions, aquifers exist at a depth of perhaps a few hundred yards (or meters). Many researchers suspect that these could be formed when geothermal heating melts underground ice, or permafrost, from the bottom up.

It makes sense, incidentally, that the youngest water activity should have roughly the same age as the youngest lavas. There is good evidence that



A 200-mile portion of Elysium Planitia (left), holds strong evidence of recent lava flows. A detailed MGS image of the box at lower left shows fresh lava only tens of millions of years old (right). NASA/JPL (left) and NASA/JPL/MSSS (right)

underground ice exists in widespread permafrost regions on Mars and that water has been incorporated into minerals in the soil. It would be very difficult to bring magmas up to the surface of Mars without melting some ice and releasing some water along the way.

The four revolutionary facts aren't the only evidence that Mars is a more dynamic planet than we thought. The magnetometer onboard MGS discovered that the crustal rocks preserve magnetism created by a very early magnetic field. This field was gone by the time the gigantic Hellas basin formed about 4 billion years ago because the Hellas impact punched a hole in the magnetic pattern preserved in the crust. According to theory, a planetary magnetic field must be generated by a molten planetary core, and this establishes that the interior of early Mars was at least partly melted. Thus it appears plausible that radioactive heat sources could have kept the mantle of Mars hot enough to continue to provide molten material that fed sporadic volcanic eruptions, dotted down through martian geologic time.

The MGS laser altimeter has mapped precise altitudes across the entire planet and gives compelling, if still controversial, evidence that large amounts of liquid water — or ice-choked seas — existed on the surface in ancient times. The water flowed off the southern highlands and collected in seas in the northern lowlands. The best indication is that a large, smooth-floored basin around the north polar area has a shelf around it, similar to coastal shelves that might be formed by delta deposits along the shore of a sea. Prior to MGS, this shelf was not clearly defined, but the laser altimeter defined it and showed it to be at a uniform level virtually all the way around the basin — as if defined by a "sea level" at an ancient shoreline.

The picture that emerges from this evidence is that underground "rivers" may have formed widely on Mars, especially in earlier times, as part of a general flow of water from the southern highlands into the northern lowlands. According to some models, this water could have been under high pressure, from the weight of overlying sediment, and may occasionally have burst forth from the ground in large volumes, pouring across the surface in catastrophic floods and cutting the larger outflow channels for which Mars is famous. For example, Ares Vallis, the north-draining riverbed at whose mouth the Pathfinder probe landed in 1997, originates in regions where the ground clearly collapsed when subsurface ice melted.

A YOUTHFUL MARS

The new picture of a "Youthful Mars" not only confirms that geologic activity, including probable ice-choked lakes and seas, glaciers, and volcanic outpourings, occurred abundantly in the first two-thirds of Mars's history, but — to most peoples' surprise — gives hard evidence that volcanic and aquifer activity has continued into the last few percent of martian time. And it probably continues today.

Obviously these findings will have a dramatic effect on the human exploration of Mars and the quest to learn whether life ever existed there. Underground aquifers — if long-lived — would offer the perfect habitat for microbial life. The Viking landers in 1976 were equipped to look for life, but they looked in the wrong place — the arid, windswept, ultraviolet-blasted surface. A NASA research team headed by Everett Gibson and David McKay shocked the scientific world in 1996 when they announced the possibility that some martian rocks contain fossilized microbes, in carbonate globules deposited by liquid water in fractures inside the rocks. Though still controversial and unconfirmed, this provocative result led to confirmation that enormous numbers of microbial lifeforms live happily underground on Earth, including inside fractures in basaltic lavas.

The next few decades will see an effort to probe the subsurface layers of Mars to look for martian microbes, either past or present. The test of whether life evolved on Mars is a perfect scientific problem because an answer either way would be profound. If life did evolve on Mars, what was it like and what was its basis at the molecular level? If life never appeared on Mars, why not, and does that mean humanity is more likely than we thought to be alone in the universe?

William K. Hartmann is a member of the Mars Global Surveyor Imaging Team. His most recent book is a novel about martian exploration, Mars Underground, *currently available in paperback.*

CAPTURED BY ALIENS

In Joel Achenbach's new book, the author explores alternative groups and their efforts to conquer space.

by Joel Achenbach

It was a perfect day on the eastern flank of the Rocky Mountains, which was pretty much a perfect place even in a cosmic context. The skies over Boulder, Colorado, were blue and clear all morning, and when the clouds rolled in they were gentle and puffy, the kind of clouds that you don't take seriously, that don't really register as being suspended liquid-water droplets. The air was perhaps a bit thin — more than a few millibars under the sea level average — but otherwise it was clean, snappy, scrubbed by evergreen forests. People wandered the pedestrian mall along Pearl Street, dipping into bookstores, eating ice cream, watching street performers. Bikers pedaled up a winding path into the foothills next to a tumbling stream that is popular with kayakers. Hikers rambled through the meadows of Chautauqua Park, climbing to better views of the knife-edged Front Range and, to the east, the limitless high plains.

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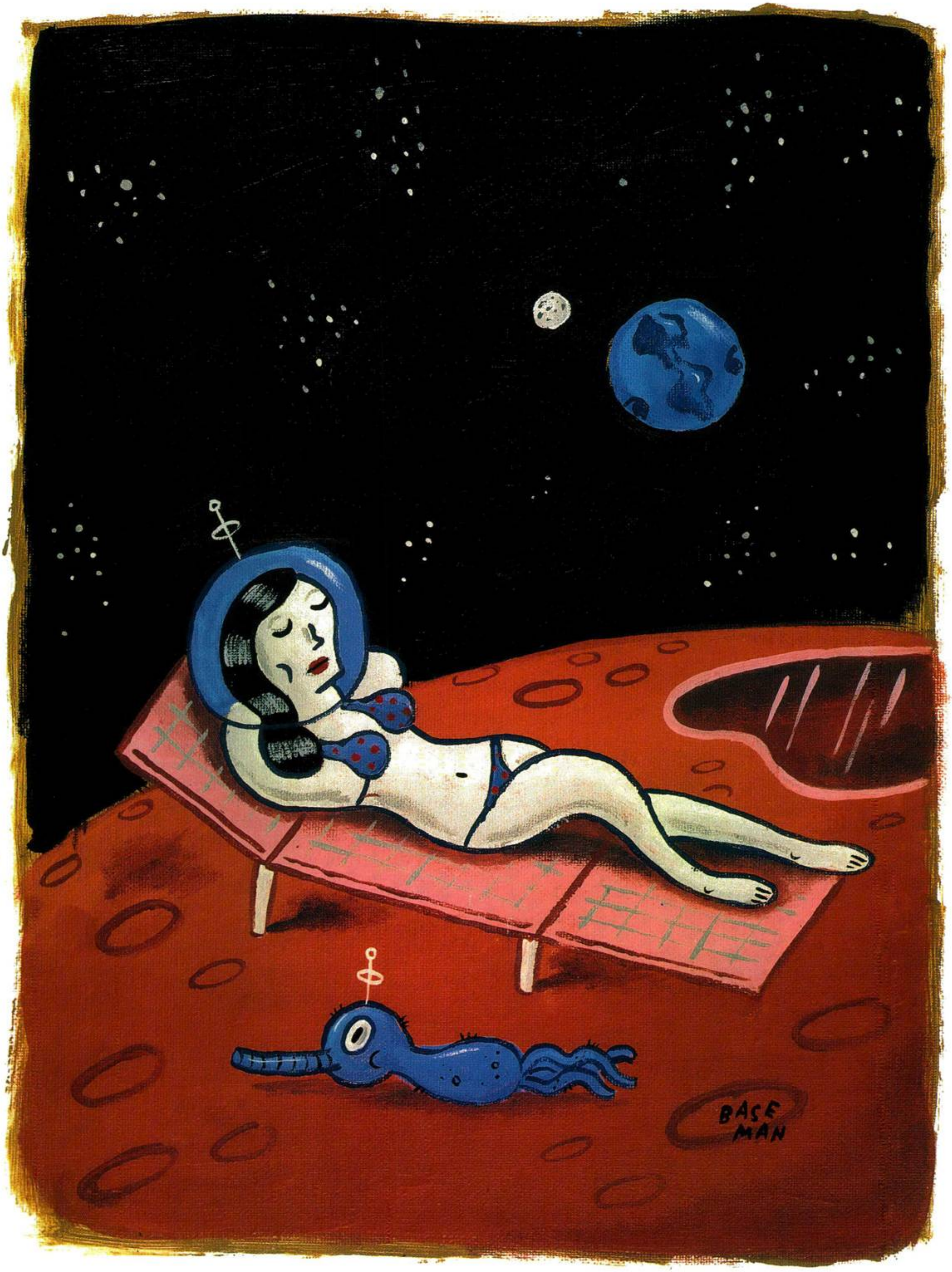
Gary Baseman


BASE
MAN

But even on this perfect day there were people who did not go outside. Instead they gathered in a ballroom on the campus of the University of Colorado. They stayed inside all day long and into the night. They had a goal: Go to Mars.

They wanted to leave Boulder behind and go to a small, cold planet with no pedestrian malls, no tumbling streams, no forests, no mountain parks, no Mexican restaurants or brewpubs, not even weekday delivery of the *Wall Street Journal.* They wanted to go somewhere with no air. Forget kayaking — there's no liquid water on Mars at all, except perhaps in the pores of rocks far below the surface. An unprotected person would more or less instantly die on Mars. Then the remains of the person would be fried by solar radiation, so that even the bacteria would die. The flesh would freeze. The temperature is routinely more than a hundred degrees below zero. Dust storms sometimes envelop much of the planet. It has been observed that Mars is a lot like the moon, only with bad weather.

Not that this would diminish the enthusiasm of the people in the ballroom. They had come here to form a new organization, the Mars Society. They had signed their Founding Declaration. They wore buttons: "Mars or Bust." And they had a leader: the charismatic Robert Zubrin. He was arguably a practical man in terms of futuristic space travel, because he wasn't talking about going to Alpha Centauri, he wasn't claiming to have discovered an inertia-canceling scientific theory, and in fact he was perfectly happy to employ the old-fashioned principle of rocket propulsion. The only impractical part of his program was that he wanted to go to Mars.

Zubrin had figured out the How of the matter. He knew the When. Mars was the Where, we humans were the Who. The toughest question, however — and perhaps it seemed particularly pressing on this sunny day in Boulder — was the Why.

Mars Direct

Zubrin took the stage. About five hundred people were in the ballroom, and most had read Zubrin's book, *The Case for Mars.* There were boxes of it stacked by the ballroom entrance. This was clearly Zubrin's show, a Zubrinfest.

Zubrin conceived the Mars Society in early 1998 and appointed himself president, unpaid. He lined up a steering committee that included NASA scientists Chris McKay and Carol Stoker and science-fiction writers Kim Stanley Robinson and Gregory Benford. Hundreds of people sent in abstracts of talks they wanted to give at the convention, and Zubrin weeded out the ones that might tarnish the proceedings, including the proposals from the Face on Mars folks, the Planet X people, the antigovernment paranoiacs, and various people with nothing coherent to say. He knew he needed a good screening process, because advocating human migration to Mars was strange enough.

Now he had his moment, his audience. He looked out upon a vast room of true believers. "I believe this is going to be an historic occasion," he said.

The sound system immediately failed, a squealing mess (was it the same saboteur who struck at the Mars meteorite press conference?). Undaunted, Zubrin tossed his microphone away and shifted to a controlled shout, which seemed to suit him just fine. At first he was a bit stiff, shifting his weight from foot to foot, hands in pockets. But as he warmed up, the hands came out and hacked at the air. Zubrin began roaming the stage, scowling, cracking jokes, extemporizing, speaking at manic velocity, without notes. This was part technology lecture, part sermon. If he had looked at first like a nerdy engineer, he managed, over the course of the hour, to reveal himself as a brilliant evangelist of interplanetary travel. It is time, he said, "to take the steps to make man a multiplanet species."

He explained how NASA had gone wrong. He cited the Space Exploration Initiative of President Bush, that ill-fated proposal in 1989 to build a bunch of orbiting space stations and giant interplanetary vessels that would cost an obscene amount of money — what Zubrin called "the parallel universe." He showed a slide of an enormous spacecraft. "I call it the Death Star," he said. No wonder NASA had failed to get its manned Mars mission past Congress, he said.

Zubrin said he had a better plan. He called it Mars Direct.

Zubrin's vision requires no space stations or moon bases or even any advanced propulsion techniques. Instead, he would launch an unmanned craft to Mars using existing rocket technology ("unpiloted" is the preferred term these days, but I find it confusing, since it suggests the craft contains wide-eyed passengers who are wondering who's flying the damn thing). It would land on Mars and set up shop as a manufacturing station of fuel, using just the elements naturally available on the martian surface. Zubrin said this process is not that difficult; you can make propellant with martian dirt. Only when this stage of the project had been successful would a crew of astronauts zoom to Mars on a second rocket. The genius of the Zubrin strategy is that the astronauts don't have to bring the fuel they'll need for the return journey — it'll be waiting for them.

This, said Zubrin, is the same strategy explorers have used on our planet for centuries: "Live off the land." (In his book he put it another way: "When on Mars, do as the Martians do.")

Zubrin the engineer speaks with authority. But to be the leader of the Mars Society, of an entire movement, Zubrin has to be something more, a spiritual force, a moral philosopher, a Sagan figure. Zubrin doesn't shy away from that role. Onstage, he outlined the reasons why we should — why we must — go to Mars. First, he said, there's science. If we go to Mars, we can discover whether there was ever any life there. Viking didn't settle that issue. If we find signs of life, present or past, it will indicate that life, including intelligent life, is probably spread across the universe. "It means we're not alone, we're part of something bigger than we suspect right now."

But then comes the grander agenda — a matter that would, in coming days, spark much argument and acrimony. Zubrin said the issue at hand is not whether life used to be on Mars but whether it will be on Mars in the future — human life. He said he believes we should settle Mars, that we should "terraform" the planet to make it habitable for humans and other forms of life. It's our destiny, he believes. Mars, he tells everyone, is not just a planet but a world, a place of unlimited potential, a place where good things can happen in the same way that a great nation rose upon the North American frontier. Humans, Zubrin said, are now a "Type I civilization," capable of taking advantage of all the resources of our home planet. But to become a Type II civilization requires that we extend our reach across our solar system. "We have mastered our own environment," he said. "Will we settle for that or will we reach out further and become a Type II civilization?"

Zubrin's vision requires no space stations or moon bases or even any advanced propulsion techniques.

He shared his vision: "Two thousand years from now, there will be people not only on Earth and Mars and the asteroids, there will be people in civilizations orbiting hundreds of stars in our region of the galaxy."

He finished to a standing ovation.

Up to Their Nostrils in Mud

We were supposed to be on Mars already. In 1952, the German rocket scientist Wernher von Braun published *Das Marsprojekt,* a plan to send ten spaceships, each with a crew of 70, to Mars. Going to the moon would be just a preparation for this Martian adventure. In 1962, NASA began preliminary studies on the feasibility of manned voyages to Mars. In 1969, a couple of weeks after the moon landing, von Braun testified in Congress that it would be possible to have a manned fly-by of Mars in 1978 and a landing in 1982.

It never came to pass. NASA gave up on Mars. In the mid-1990s, with Mars having returned to the forefront of scientific interest, there were some blue-sky discussions at NASA of a manned Mars mission in 2014, or maybe in 2018. There were people at the Johnson Space Center who started putting together tentative plans for such an adventure. But Goldin knew that there was not yet the political support for any grandiose initiative. He liked Zubrin's idea and spoke enthusiastically about Mars Direct, but Goldin seemed to feel that too much talk about Mars would alarm the bean-counters in Congress.

It was easy to see why Zubrin was frustrated. He knew that the space program had achieved wonderful things in the dozen years from 1961 to 1973. Scientists and engineers invented spaceships, orbital rendezvous techniques, space suits, hydrogen-oxygen rocket engines, multistage heavy-lift boosters, life-support systems, interplanetary navigation, soft-landing technology, nuclear rockets, rovers, and on and on. Zubrin can make a Mars mission sound like simple pragmatism. Americans already pay $13 billion a year to NASA for a space program. A lot of that money, Zubrin said, maintains an infrastructure that was originally designed precisely for manned planetary exploration. We paid for it, he says, so why not use it?

But going to Mars is not like taking a Sunday drive to the zoo. To get to Mars, a human crew would need to spend at least 150 days in interplanetary space, cut off from supply lines, locked in a can, and forced to drink water from recycled urine (among other unsavory prospects). If a solar flare erupted, the astronauts would have to cram their bodies into a tiny central compartment for protection against lethal radiation. One speaker, Mike Griffin, a former NASA associate administrator, told the conventioneers that American society has become excessively risk-averse. We are cringing and weak, soft and nervous. We have forgotten the hardships of our ancestors. Griffin told a story about Jebediah Smith's attempt in the early 19th century to find a route to California from Colorado across the deserts of Utah and Nevada. He and his party followed the Humboldt River, which ran in the right direction, toward the Pacific. But then the river dried up. It just died out there in the middle of the scorching nowhere. The men ran out of water. To survive, they killed their mules and drank their blood, and two of the men jammed on their wide-brim hats, buried themselves in mud up to their nostrils to stay cool, and waited while Smith hiked 60 miles on foot to the Sierras and replenished their water supply. He returned with the water and found the men not quite dead. "How many people think a trip to Mars will be anything near that grueling?" Griffin asked.

The people in the audience did not have to be sold. They were ready to work night and day for a Mars mission. They were ready to put on jumpsuits and go. They were ready to be buried up to their nostrils in mud.

They all had their reasons. Over a beer after midnight, one scientist said that if we go to Mars, "it means we are immortal": No asteroid could ever wipe out all of humanity. Another man, a libertarian, told me, "You won't be able to have bureaucrats on Mars regulating everything." He wants a Mars mission to be solely a private venture. The idea I found most provocative was the assertion that young people in America need a Mars mission, that they need a cause, a rallying point, something analogous to the Vietnam War protests or the civil-rights movement. A high-school student told me, "The kind of opportunity to challenge yourself and push the limit of human ability, you can't get it here on Earth."

In the span of half an hour, the panelists had managed to advertise the soft underbelly of the Mars movement.

Martian Manifest Destiny

The low point of the convention came Friday night, at the terraforming debate. Terraforming Mars is a popular concept with the Mars enthusiasts. The idea is that Mars can be made habitable through a massive program of introducing organisms, increasing atmospheric pressure, warming the planet, and gradually constructing a more Earth-like environment. There are two problems with terraforming. First, it's exceedingly difficult, because you can't simply plant some seeds. It would be easier to turn Antarctica into a tropical paradise, or to build great cities at the bottom of the ocean. The visionary Zubrin is the first to admit that his young daughter will never splash in Martian lakes.

The other problem is the principle of the thing. Would it even be ethical? This was the subject of the debate. Mars, though apparently lifeless, could have native organisms in the permafrost or deep beneath the ground. Terraforming might wipe out that indigenous life. Some, like Sagan, have said that if life exists on Mars the planet should be left alone.

There were five panelists on stage, plus moderator Chris McKay. The night got interesting when Zubrin took the microphone. He said he believes that some things in the world are simply better than other things, and the societies that believe in science are more successful than the ones that believe in mythology. Humans, he said, were something more elevated than animals, and certainly than microbes. Western civilization, with its humanist orientation, is the only one that people in the room would want to live in. If we alter Mars, he said, we are actually acting on behalf of other forms of Earthlife. We can take fish there, for example. "We eat a lot of fish. But we can return the favor by establishing fish on Mars. They can't get there any other way. It's payback time."

Then came Lowell Wood. Wood promised to make Zubrin sound like a moderate. Humans, he said, have increased in number one-hundred-thousand-fold in the last hundred thousand years, and the reason is terraforming. By altering our environment, we increase the odds that our children will not starve to death. "At least half of all kids ever born starved," he said. The people who terraformed their environment had a higher percentage of surviving children, and therefore they increased their representation in the gene pool. One of his viewgraphs stated that terraforming Mars is "the sociobiological manifest destiny" of Homo sapiens, "the terraforming species." He boasted that the United States has a society that builds new worlds. Americans made America! "We built it into the shining city on the hill on this planet."

No one applauded. Wood had the audience a bit rattled. What was all this talk about starving kids? Manifest Destiny? Shining city on a hill?

In the span of half an hour, the panelists had managed to advertise the soft underbelly of the Mars movement. The technocrats hadn't mastered a jot of the science-meets-religion language of the 1990s; they had no feel for New Age sentiments. They sounded angry. The drive to colonize another world requires an aggressiveness, a grasping nature, that many people find distasteful. Colonization meant tragedy for millions of indigenous people around the world. "Manifest Destiny" is generally associated with the belief among European-Americans in the early 19th century that they had a divine duty to spread their society across the continent. One effect of settling the frontier was the genocide of Native Americans. Sagan, for one, understood the historical tragedies of colonization, and he believed that this time we should get it right, that we should be cautious in our interplanetary aspirations, that we should have as our paramount concern the respect for indigenous extraterrestrial life.

McKay asked for questions and comments. A park ranger stood up. He said he objected to the use of the term "Manifest Destiny," and added that the shining city on the hill is sometimes invisible for all the smog.

Zubrin jumped in.

"Denunciation of Manifest Destiny is a fashionable pose," he said, "but by opening the American West we made a place where millions of Mexicans are trying to get in."

A man in the audience leaped to his feet and said, "That's good, because they'll replace all the millions of Indians we killed in the process."

At that point no one in the room could avoid contemplating the demographic situation onstage. All six panelists were white, male, and American. They represented pretty much the entire spectrum of white American male technophiles who want to colonize Mars.

Things got even testier. A schoolteacher, Judy Paulsen, objected to the panel's "arrogant" rhetoric. Another woman, Victoria Friedensen, an officer with the National Academy of Engineering, stood up and complained about the brute-force approach to terraforming Mars. "I find some of the use of technology terrifying. And I find it deeply, deeply arrogant." Zubrin, who appeared increasingly exasperated by the discussion, responded: "What do you find offensive about making Mars into a living world?" Friedensen said, "I would ask that you perhaps modify your language so that the rest of us, who are not as technologically oriented, can join in."

This riled Lowell Wood. He had been misunderstood, he said. There was not a moral imperative to terraform, there was a genetic imperative. Then he said something that brought gasps from the crowd. Apparently he wanted to make the point that it didn't matter in principle if Mars was terraformed gently or brutally, so he cited a famous line by George Bernard Shaw: "Madam, we have established what you are, we are merely haggling over the price."

A whore metaphor? What was going on? Whatever Wood's precise intention may have been, many people heard the comment as an insult to Friedensen. One woman stormed out of the room. She said later, "There were six white males with testosterone flowing, talking about Manifest Destiny. You're transporting me back a hundred years!"

Afterward, many people walked up to offer Friedensen their support. "Frankly, I was scared by some of the rhetoric here tonight," said David Grinspoon, a planetary scientist. Sam Burbank, a documentary filmmaker and musician, said, "I was dying over here. This was a disaster. This was my worst nightmare of what this convention would be like."

The Founding Declaration

The next morning Zubrin felt dispirited. He knew the debate had been awfully acrimonious. He sought out Friedensen and apologized to her. But over the course of the day his spirits lifted. New organizations always wobble at first. What he had seen was ideological diversity. That was a strength!

The steering committee met for many hours and developed a plan. The society would start off with the establishment of an Arctic base to simulate conditions facing Mars explorers. Next would come some kind of unmanned exploratory mission to Mars. The society would earn a solid reputation, gain support, raise money, and eventually put together a mission for humans. This was Chris McKay's dream. The organization would be like the Cousteau Society, doing real things with real people.

By nighttime, with the convention banquet going full-bore, Zubrin was peppy again. About 700 people had come to the founding convention of his society. The way he saw it, his organization included people who had made A-bombs and people who had gone to jail rather than fight in Vietnam, and they all wanted to go to Mars. "To get to Mars, we're going to need poets and pilots," he said.

He felt bad about the fish comment — too flippant. But he couldn't bring himself to change his tune on Manifest Destiny. "There are people here who are more politically correct than I am," he said. Manifest Destiny was a belief system that motivated ordinary people to pull up stakes and set off on a perilous journey to the frontier. The world has benefited from that, he said. "It was tragic for the Indians. But there are no Indians on Mars. And to compare microbes to Indians shows extreme disdain for the Indians."

After dinner it was time to ratify the Founding Declaration of the Mars Society, written by Zubrin and author Kim Stanley Robinson. Zubrin read it aloud, onstage, in his most dramatic, declarative voice:

"The time has come for humanity to journey to Mars!" he began. He gave all the reasons: for knowledge, for the challenge, for the youth who demand adventure, for the opportunity to carry the best of our heritage to a new world.

"Mars is not just a scientific curiosity," he read. ". . . It is a New World, filled with history waiting to be made by a new and youthful branch of human civilization that is waiting to be born. We must go to Mars to make that potential a reality. We must go, not for us, but for the people who are yet to be. We must do it for the Martians."

When he finished, everyone jumped up and applauded. Zubrin called for a voice vote. The ayes had it, unanimously. Zubrin was ecstatic. The crowd was pumped. They had a society. They had a movement. They were going to Mars, a cold little planet millions of miles away — but a world, they believed, that would someday be wonderful.

Joel Achenbach is on the staff of The Washington Post. *He is also the author of* Why Things Are *and is a frequent contributor to National Public Radio.* Captured by Aliens *is available from Simon & Schuster.*

Missing the Mark

Several failed missions to Mars have forced NASA into a sobering reality check.

by Rex Graham

Photo by Jim Forbes

More than 30 years after Apollo 11 astronaut Neil Armstrong took that one giant lunar leap for mankind, NASA is stumbling in its efforts to explore the next solar system frontier — Mars. Scientists want to search for signs of life, retrieve rocks, and eventually send astronauts to the Red Planet, but NASA's 16-year plan to accomplish those goals is in turmoil. Why? In 1999, NASA lost three missions back to back to back: Mars Climate Orbiter, Mars Polar Lander, and Deep Space 2.

And that's not all. Several other recent NASA missions have been lost because of embarrassing navigational miscalculations or technical glitches. NASA plans to launch a Mars orbiter on schedule in 2001, but it postponed a 2001 Mars lander and other missions while it tries to get in touch with its inner Right Stuff.

The faster-better-cheaper NASA, the NASA that lost the trio of Mars probes, the NASA that is supposedly doing more science with less money, is overdue for its current reality check. Of course, it's a much less wrenching psychoanalysis than that which followed the 1986 Challenger disaster, but no less necessary. A slightly more expensive and more successful path to Mars has already begun to emerge.

President Clinton and congressional leaders continue to support NASA Administrator Daniel Goldin, the architect of the faster-better-cheaper approach to space and Earth-science missions. The hard-charging Goldin has accepted responsibility for the recent spate of failures, but that hasn't improved his standing among planetary scientists.

Possibly no group is as important to NASA's recovery as the engineers, scientists, and managers of the Jet Propulsion Laboratory (JPL) in Pasadena, California. Overseen for NASA by the California Institute of Technology, JPL provides day-to-day management of the United States' robotic exploration of the solar system from a 177-acre campuslike setting 12 miles northeast of Los Angeles. As much as NASA itself, JPL suffered a humiliating loss on December 3, 1999, as Mars Polar Lander and its piggyback Deep Space 2 probes arrived right on target. TV cameras, called in to capture a joyous celebration at JPL mission control, were ready. To the camera operators' surprise, they captured disbelieving expressions frozen on the faces of JPL and NASA employees, including Goldin. Polar Lander and its twin Deep Space 2 microprobes vanished without a radio peep.

NASA may never know what happened because Mars Polar Lander didn't have a device to transmit radio signals to Earth during its final descent. (A mishap-investigation report states that not including the transmitter "helped Mars Polar Lander meet cost, mass, and schedule constraints, but failed to provide feedback that would be useful in the design of future missions.")

Simulations conducted in February by Lockheed Martin Astronautics, prime contractor for the three recently failed missions, revealed that Polar Lander most likely shut off its descent thrusters too soon and crashed. The finding takes into account a nettlesome problem involving the spacecraft's three landing legs: When they deploy, they generate signals that falsely indicate they have touched down. The problem was known, but its affect on the main computer's decision-making process was not. The Lockheed Martin tests, which involved a simulated landing of a similar spacecraft, suggest that the fatal glitch occurred when Polar Lander's descent-engine thrusters slowly lowered it to 132 feet above the planet's surface. At that point, the onboard computer interpreted the signals from the landing legs to mean that the craft had landed. The computer immediately turned off the thrusters and the spacecraft began to fall. A moment later it would have smashed into the surface at 50 miles per hour.

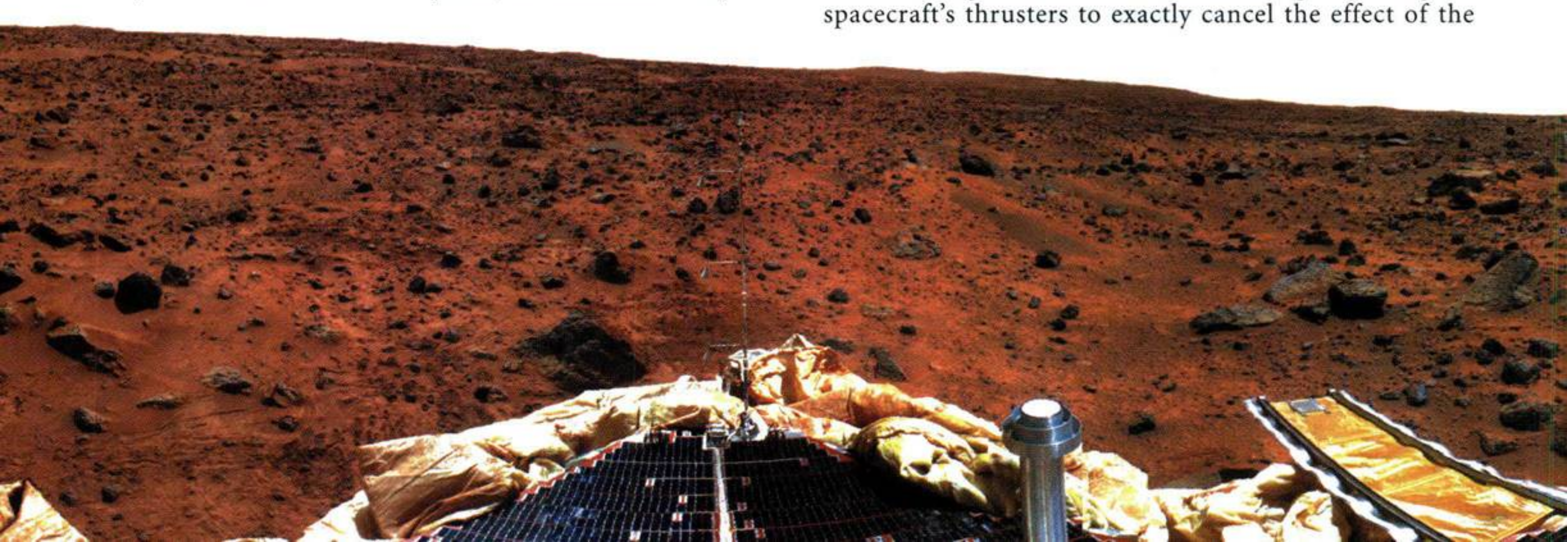
The Deep Space 2 microprobes carried aboard Mars Polar Lander most likely failed for different reasons, according to a JPL review board. They either ricocheted off the planet's surface (an inch of dusty material covering the rocky impact area may have acted like a lubricant and prevented penetration), suffered an electronic or battery failure (the batteries were delivered too late to be impact tested before launch), or the antennae broke down in the martian atmosphere (they were never tested in a similar environment).

The Mars Climate Orbiter failed upon its rendezvous with the planet on September 23, 1999. Edward Weiler, NASA's Associate Administrator for Space Science, initially said a "simple error" involving the use of English instead of metric units in navigation-modeling software made the spacecraft fly in too low. Indeed, a report by a mishap-investigation board confirmed that the units error was the "root cause" of the failure. However, the board also noted eight "contributing causes." For example, the report says JPL assigned only one employee to the critical task of navigating the spacecraft. Unexpected complications quickly overwhelmed that person.

Like a highway motorist adjusting a car's steering wheel to keep the vehicle in the proper lane, the navigator initiated four trajectory-correction maneuvers during the mission. Because the spacecraft was too far away to be observed directly — even with a telescope — the navigator used special software to plot the craft's trajectory after each thruster firing. Unfortunately, the software had the English-units error.

Like other spacecraft, Mars Climate Orbiter held itself in proper alignment toward the sun, its energy source, by a series of "momentum wheels." These rapidly spinning, electrically powered flywheels take advantage of the law of conservation of momentum: When a motor spins a heavy disk slightly faster in a given direction, the spacecraft turns slowly in the opposite direction. An unforeseen complication arose from Mars Climate Orbiter's solar-power panel: It was mounted asymmetrically. This architecture made the radiation pressure coming from the sun continually turn the spacecraft like a rowboat being rowed with one oar instead of two.

The momentum wheels counteracted the effect of the panel asymmetry. The navigator periodically slowed the wheels to keep them working optimally. These maneuvers are called angular momentum desaturations (AMDs). The navigator performed each AMD by simultaneously applying a brake to a given momentum wheel and gently firing the spacecraft's thrusters to exactly cancel the effect of the



braking on the spacecraft. The navigator had to perform 10 times more AMDs than expected because of the solar-panel asymmetry. Unfortunately, the use of English instead of metric units in the navigation software led the navigator to underestimate the effect of each AMD by a factor of 4.45.

While each of the four trajectory corrections put the spacecraft back on course, the navigator didn't know that each subsequent AMD caused more trouble. The navigator simply knew that there was an unsolved problem and told his supervisors about it. They met with their Lockheed Martin counterparts and repeatedly asked them which units — English or metric — they had used. Lockheed Martin officials repeatedly reassured them that they had used metric.

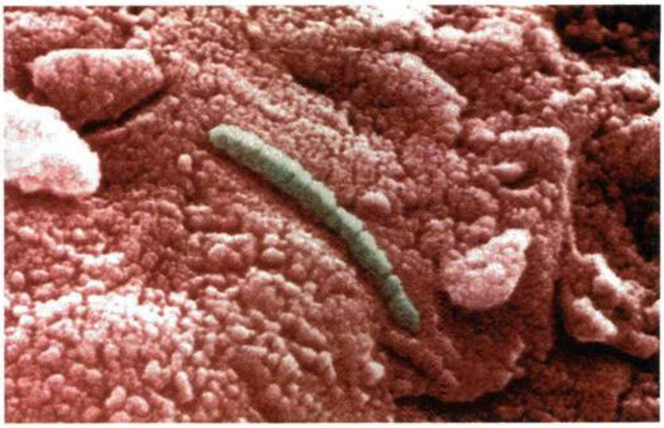
The spacecraft picked up speed the closer it got to Mars. The navigator kept track of the speed by monitoring the Doppler shift of its signals sent back to Earth, but that signal gave no measure of the spacecraft's movement perpendicular to its line-of-sight with Earth. The navigator and the project scientist proposed an unplanned, fifth trajectory-correction maneuver, but mission managers overruled their recommendation. It is uncertain whether a fifth trajectory correction would have saved the spacecraft, but it would likely have increased its chances of survival.

The final main-engine "insertion" burn at the end of the 9½-month trip was designed to slow the spacecraft and drop it into a 226-kilometer-high elliptical orbit around Mars. Unfortunately, the spacecraft entered Mars's atmosphere 170 kilometers lower than planned and either overheated or bounced off the atmosphere into space.

Breathtaking Risks

In theory, Goldin's faster-better-cheaper idea was a good one: cut development times (although congressional budget cuts and a freeze on launches after the Challenger disaster were responsible for delaying some missions), reduce mission costs (which was relatively easy because most missions were scientifically stripped down), and increase the pace of discovery by flying more missions in less time (although the pace of discovery has been slower than the public might think because the scientific payload on each mission is smaller).

In practice, investigative panels found that NASA pushed JPL employees too hard. "The focus on cost and schedule reduction increased risk beyond acceptable levels on some NASA projects," says a report on the faster-better-cheaper approach written by a team of experts led by Mars Pathfinder mission leader Tony Spear. Under the cost and schedule pressures, the panels found that in some cases mission managers relied on one person — such as the Climate Orbiter navigator — to perform tasks that on less challenging missions had been accomplished by a team. Managers also failed to provide for adequate communication among stressed team members, and they launched spacecraft with equipment they knew had been inadequately tested. In hindsight, the conduct of the managers looks breathtakingly risky. "Even now, NASA may be operating on the edge of high, unacceptable risk on some projects," says the Spear report.

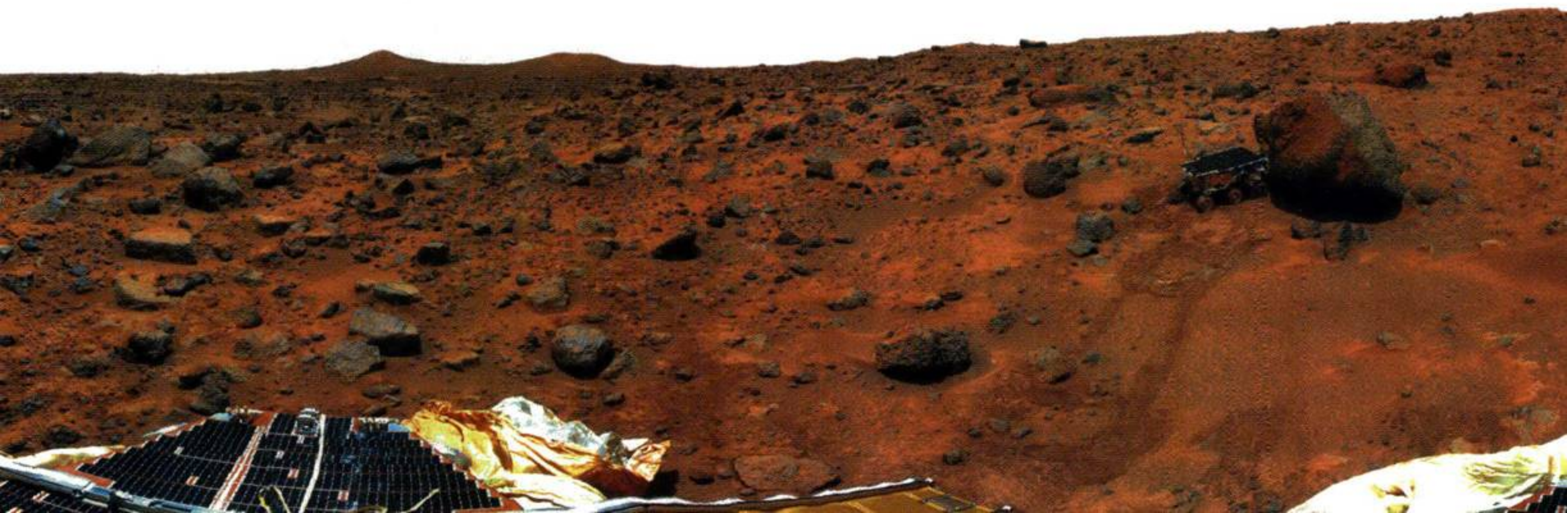


The discovery of this possible microfossil in a martian meteorite energized NASA to embark on an ambitious Mars program. NASA/JSC

Thomas Young, a retired Lockheed Martin executive who led a team that examined NASA's entire Mars program, says the failed missions were at least 30 percent underfunded. Mission engineers were forced to work 60 hours a week or more. Still, many didn't have enough time to recheck their work in the painstaking way they would have preferred. "The mistakes that took place on Mars Climate Orbiter and Mars Polar Lander were mistakes in areas where we know how to do things correctly," says Young. "Taking risks with things you know how to do are not the kind of risks to take."

Another report signed by 11 top NASA managers was a more direct rebuke to Goldin. Arthur Stevenson, Director of NASA's Marshall Space Flight Center, led the group, which included colleagues at Marshall, NASA's Ames Research and Goddard Space Flight Centers, and NASA headquarters. After reviewing eight NASA missions, particularly Mars Climate Orbiter, the group recommended "Mission Success First" as a new NASA mantra. The Stevenson report states that the faster-better-cheaper approach "shortchanged" critically needed testing and scrapped "old, proven" management techniques in favor of "new, unproven" ones.

Mars Pathfinder (seen in the foreground) proved one of the crowning achievements of NASA's faster-better-cheaper mentality. NASA/JPL



Mars Climate Orbiter entered the atmosphere too steeply. NASA

Mars Polar Lander apparently crashed into the surface. Lockheed Martin

Republican Senator John McCain said during a senate committee hearing on March 22 that he was "startled" by the recurrent problems. "Over the past year, I have continually been amazed by the reports coming out of NASA about mission failures and program delays," McCain told Goldin. In testimony before the panel, Goldin conceded that NASA's workforce reduction during the past seven years from 25,000 to 18,500 employees left the agency "too thin." He told senators that the agency plans to hire 2,000 new workers and make a host of improvements.

After testifying, Goldin traveled to Pasadena a week later and quoted Theodore Roosevelt in a speech intended to rev up the JPL troops. "We may have pushed too hard," Goldin said in the speech broadcast by NASA TV to NASA and JPL offices nationwide. "We expected two or three setbacks for each 10 missions, but we're well aware that the failure rate has gone up significantly in the last few years." He promised that, for space missions, NASA will require more training, better communications, and enhanced oversight and review. JPL employees applauded politely as the TV cameras filmed.

Years Spent for Naught

Meanwhile, astronomers grumble. Their careers, personal lives, and enthusiasm for research have suffered as mission after mission didn't deliver. "I have seen years of preparation go for naught," says James Bell, an astronomer at Cornell University whose instruments flew on the successful Mars Pathfinder mission and the ill-fated Mars Climate Orbiter and Polar Lander missions. "I can sympathize with both perspectives — faster, better, cheaper is the way to go, and faster, better, cheaper is cutting corners too much."

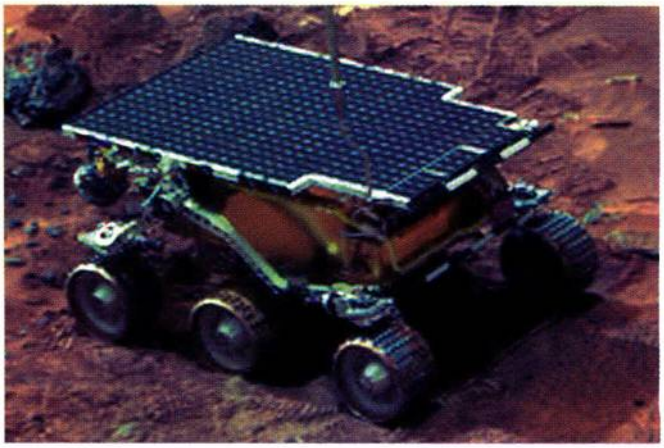
NASA's troubles extend beyond the missions to Mars. Some low-profile missions have failed with little attention. For example, in 1999 the ionosphere-research satellite called TERRIERS was lost. It, like the Mars missions, would have benefited from a budgetary cushion as engineers and scientists grappled with a host of unexpected problems before launch. "There are a million details in one of these things and you must pay attention to every single one," says Daniel Cotton, a physicist at Boston University's Center for Space Physics and principal investigator for TERRIERS. "It takes time, it takes effort, and, at the bottom line, it takes money."

More than four years of Cotton's and his students' efforts went for naught when their $6.1-million satellite spun out of control and died almost immediately after it was launched in May 1999. Cotton says that an aerospace company under contract to NASA mistakenly used a minus sign instead of a plus sign in the software of the satellite's computer-controlled navigation system. Although Cotton's group subjected the system to laboratory tests, it didn't have enough money to perform a dynamic test that would have exposed the mistake. "I think of the Apollo program [which cost roughly $200 billion in 2000 dollars] and it blows me away that NASA could actually do that," says Cotton. "It doesn't take much to bring everything down."

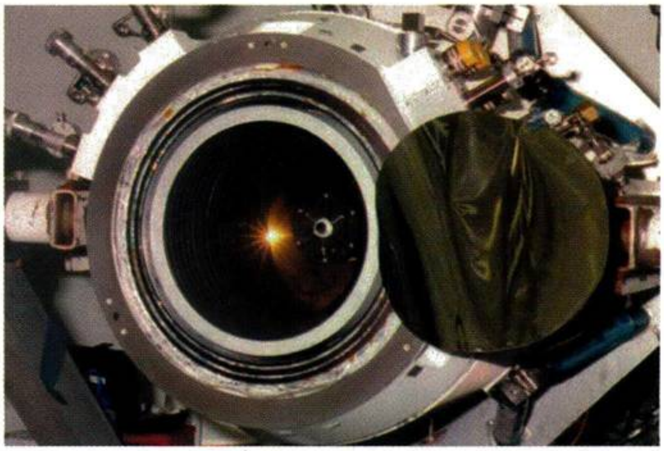
The $73-million Wide-Field Infrared Explorer (WIRE), built by JPL and Utah State University and designed to study galaxy evolution, failed shortly after its March 1999 launch. A mishap-investigation report said a premature electronic instruction caused the faster-better-cheaper spacecraft to prematurely jettison the aperture cover of its cryogenically cooled 30-centimeter telescope. The motion of the heavy aperture cover caused the spacecraft to spin out of control and lose its four-month supply of solid hydrogen coolant in 36 hours. Investigators found that an unexpected power surge from a $2,000 electronic circuit made the cover pop off.

Of course, NASA successfully managed projects such as the Hubble Space Telescope and its upgrades (thanks in part to astronauts who helped fix the telescope's optical flaw), the Galileo spacecraft (whose main communications antenna failed to open, requiring that data be transmitted to Earth with a much slower backup antenna), the Chandra X-Ray

Sojourner studied the rocks around the Pathfinder landing site. NASA/JPL



TERRIERS failed when it spun out of control after launch. Boston University



WIRE lost its vital coolant thanks to an electronic glitch. NASA/JPL/GSFC

Observatory, Mars Global Surveyor, Mars Pathfinder, Lunar Prospector, and the Stardust mission.

The price tag of the three recently failed Mars missions was roughly $350 million. That amount is relatively small compared with NASA's $14-billion annual budget, which includes about $3 billion for the space shuttle program and $2.2 billion for the International Space Station. The relative bargain of faster-better-cheaper projects has enabled them to fly under the radar screen of the General Accounting Office (GAO), the investigative arm of Congress. "No, we have not looked at smaller, faster, better, or whatever that stuff is — how successful that approach is and how far you can take it," says Richard J. Herley, assistant director of the GAO's National Security and International Affairs Division. "All of our auditing work is mandated by the congressional committees, and the overwhelming interest of Congress is in the International Space Station and the space shuttle."

The recent Mars-mission losses were more troubling because they came after the 1993 failure of the Mars Observer. That spacecraft was estimated to cost $450 million at most (an increase from the $300 million original estimate), but the price tag rose to $1.3 billion due to the added cost of the launch vehicle — the space shuttle. Following that failure, NASA managers thought it would be prudent to relaunch Mars Observer in three pieces — Mars Global Surveyor, Mars Climate Orbiter, and Mars Orbiter 2001 — aboard rockets. Interestingly, NASA estimated the cost of replacing the three spacecraft at roughly $450 million. In this case the savings of faster, better, cheaper were nil. Indeed, the risk of a failure may arguably have risen because three launches were required instead of just one.

Global Surveyor continues to send observations from Mars. NASA/JPL/MSSS

No Small Issues

Daniel Harel, vice president of Space Systems and Operations at GE American Communications Inc. (GE Americom), says space is a challenging place to do business as well as conduct planetary science. GE Americom's fleet of satellites transmits communications for a variety of clients, including Internet providers, TV and radio networks, and print media companies. "The bottom line is this is a risky, difficult, and complex business," says Harel. But he adds that every operational or testing result that deviates from the expected, no matter how minor, is a red flag. "For example," he says, "if a guy calls me from the floor of a manufacturing plant and says, 'The thermal predictor is not really matching the thermal vacuum test. It's only 1 degree, but it's not really matching it.' We will stop and investigate because the discrepancy is a symptom of something. Is your assumption wrong? Is your model wrong? Is the parameter to which you tested wrong? We don't leave it until we know."

Harel attributes his company's unblemished record of 18 successful communications-satellite launches since 1975 to a culture of open communications and perfection. Rather than relying on management by contract, remote management, or quarterly 'milestone' reviews, his managers continually walk the floors of every subcontractor's plant. They watch not only how technicians solder wires together, but also check that they first warm the solder to the optimal temperature. In addition, his company won't permit its subcontractors to cover those wires with a popular, easy-to-mold Teflon insulation because recent tests have shown that the insulation can break under stress and expose wires, possibly causing a short circuit.

"There are no small issues," says Harel. "Everything is important because these missions go into hostile environments for long periods." He says a faster-better-cheaper mantra misses the mark when customers judge a company based on its record for reliability. "Give me the best satellite you can make at the best price with the highest quality," says Harel. "Nothing is more expensive than failure." A

Rex Graham is a senior editor at Astronomy.

Just 6 Numbers

An infinite number of universes could explain why our universe appears to be fine-tuned for life.

by Martin Rees

EVER SINCE DARWIN'S TIME, WE'VE BECOME familiar with the idea that we and Earth's intricate biosphere evolved from simple beginnings. Astronomers now place our entire Earth in a broad cosmic context. We can trace back cosmic history long before the birth of the first stars and galaxies. Remarkably, the intricate universe we see around us has unfolded from a simple Big Bang.

To our surprise, we have learned that just six numbers are crucial to the "recipe" for a universe — determining how it expands; whether planets, stars, and galaxies can form; and whether there can be a chemistry favorable for the evolution of life. The outcome is remarkably sensitive to these numbers (see "The Six Numbers," page 39). If you imagine setting up a universe by adjusting six dials, then the tuning must be precise in order to yield a universe that could harbor any kind of life. If the numbers were untuned, the universe would not merely be different, it would be sterile.

This realization offers a radically new perspective on our place in the universe and the nature of physical laws. I think this fine tuning hints that our entire universe could be just one atom in an infinite and eternal multiverse.

Cosmological Progress

The evidence for a Big Bang is now as compelling as anything geologists can tell us about Earth's history. I believe with 99 percent confidence that when our universe was a few seconds old, it was a hot, dense fireball. This is an astonishing turnaround. Our ancestors could weave theories almost unencumbered by facts, and until quite recently cosmology seemed little more than pure speculation. But giant new telescopes on the ground and a flotilla of instruments in space have vastly stretched our cosmic horizons and led to a crescendo of discovery. Powerful telescopes function as time machines. They offer snapshots of

This article is adapted from Martin Rees's new book Just Six Numbers *(Basic Books, New York, N.Y., 2000).*

Because six numbers came out just right, spiral galaxies such as M83 can exist. European Southern Observatory/VLT

objects so deep in space that their light set out billions of years ago and thereby allow us to probe an era before our solar system formed.

Studying our vast universe isn't presumptuous. What makes things hard to understand is not how big they are but how complicated they are. Stars, for example, are so hot that everything they're made of is broken down into its simplest atomic constituents. Even the smallest living organism, in contrast, has layer upon layer of complex structure within it. A star is far simpler than an insect. And because the Big Bang was hotter than a star, it could have been simpler still.

Just within the last five years we've confirmed that stars other than our sun are being orbited by a retinue of planets. How many planets harbor life? This question remains unanswered — the origin of life is complex and poorly understood. Even if these planets have biospheres of some kind, that doesn't guarantee that Darwinian selection leads to intelligent beings — there may be high odds against sentient life.

The Big Bang was neither too weak nor too strong. This happy coincidence allows stars and planets to form, such as the ones forming in the Keyhole Nebula. Hubble Heritage Team (NASA/STScI/AURA)

However exotically different aliens are from us, they would be subject to the same physical laws and forces. Indeed, this uniformity, without which our universe would be a far more baffling place, seems to extend to the most remote galaxies. Alien astronomers might ask the same question we do: How did atoms assemble — on at least one planet around at least one star — into creatures able to ponder their origins? They would share our curiosity about the genesis event that led to our cosmos of galaxies, stars, and planets.

Our Well-Tuned Cosmic Habitat

There are deep connections between the inner space of atoms and the outer space of planets, stars, and galaxies. Our size is roughly intermediate between the sun, at a billion meters in diameter, and a molecule at a billionth of a meter. We straddle the cosmos and the microworld.

We depend on the sun. But what about still vaster scales? Even the nearest stars are millions of times farther away than the sun. And the known cosmos extends a billion times farther still. At first sight, these extravagant scales seem quite irrelevant to us. But we owe our existence to the stars, which forged the atoms of which our bodies are made.

The Six Numbers

$\mathcal{N}$ The cosmos is so vast because there is one crucially important number in nature that is equal to 1,000,000,000,000,000,000,000,000,000,000,000,000. This number ($\mathcal{N}$) measures the strength of the forces that hold simple atoms together, divided by the force of gravity between them. If $\mathcal{N}$ had a few less zeros, only a short-lived miniature universe could exist. No creatures could grow larger than insects without being crushed by the force of gravity, and there would be no time for biological evolution.

ε Another number, ε, whose value is 0.007, defines how firmly atomic nuclei bind together and how all the atoms on Earth were made. Its value controls the power of the sun, and, more sensitively, how stars transmute hydrogen into all the atoms of the periodic table. Carbon and oxygen are common, whereas gold and uranium are rare, because of what happens in the stars. If ε were 0.006 or 0.008, life could not exist. Either there would be no stars fueled by nuclear power, because no hydrogen survived from the Big Bang, or else there would be no elements other than hydrogen. We'd have a periodic table of one element rather than at least 92.

Ω The cosmic number omega (Ω) is a measure of the amount of material in our universe – galaxies, diffuse gas, and dark matter. Omega tells us the relative importance of gravity and expansion energy in the universe. If omega were too high, the universe would have collapsed long ago. Had it been too low, no galaxies or stars could have formed. The initial expansion speed seems to have been finely tuned to enable life to exist.

$\mathcal{Q}$ The seeds for all cosmic structures – stars, galaxies, and clusters of galaxies – were all imprinted in the Big Bang. The fabric of our universe depends on one number, $\mathcal{Q}$, which is 1/100,000. If $\mathcal{Q}$ were even smaller, the universe would be inert and structureless. If $\mathcal{Q}$ were much larger, it would be a violent place, dominated by vast black holes, in which no stars or planetary systems could survive.

λ Measuring the fifth number, lambda (λ), was the biggest scientific news of 1998. An unsuspected new force – a cosmic "antigravity" – appears to control the expansion of our universe. Even though it has no discernible effect on scales less than a billion light-years, it is destined to become ever more dominant over gravity and other forces as our universe becomes ever-darker and emptier. Fortunately for us (and very surprisingly to theorists), lambda is very small – otherwise its effect would have stopped galaxies and stars from forming, stifling cosmic evolution before it could even begin.

$\mathcal{D}$ The sixth crucial number has been known for centuries, though we now view it in a new perspective. It is the number of spatial dimensions in our world, $\mathcal{D} = 3$. Life couldn't exist in 2 or 4 dimensions. Time is a fourth dimension, but distinctively different from the others in that it has a built-in arrow: We move only toward the future. Near black holes, space is so warped that light moves in circles and time stands still. Near the beginning, and on microscopic scales, space may reveal its deepest structure of all – the vibrations and harmonies of superstrings in a 10-dimensional arena.

Before our solar system condensed from a dusty nebula, several earlier generations of bright blue stars had evolved through their entire life cycles, transmuting pristine hydrogen into the basic building blocks of life — atoms of carbon, oxygen, iron, and the rest of the elements. We are literally stardust. Less romantically, we're nuclear waste from the fuel that makes stars shine. Our galaxy is like a vast ecosystem, recycling gas through successive generations of stars. A Creator didn't need to turn 92 different knobs to make the periodic table of elements.

This entire process is controlled by the strongest force in nature — the nuclear force, whose awesome power is displayed in hydrogen bombs. This energy source has fueled the sun for 4.5 billion years and will keep it shining for another 5 billion years. The strength of this force is one of the key numbers in nature. Carbon — the element most crucial for life — wouldn't exist if this number were only a few percent higher or lower. And any substantial change would quench cosmic alchemy completely. There would be either no hydrogen or no nuclear energy sources at all to keep stars shining.

Another key number measures the strength of gravity. Newton taught us that this force not only makes apples fall, but holds the moon and planets in their orbits. Einstein gave us a deeper understanding of how gravity causes some stars to collapse into black holes. Gravity also helps govern the expansion of the universe. Gravity is crucial in the cosmos, but life depends on it not being too strong. If it pulled more fiercely, stars would burn too fast to allow time for the evolution of advanced life. Moreover, stars and planets would be far smaller than those in our universe because anything larger would collapse into a black hole. And even on the miniature planets that might exist, gravity would be so strong that it would crush anything larger than insects.

The size of the observable universe is, roughly, the *distance traveled by light* since the Big Bang. It has taken the universe somewhere between 12 billion and 15 billion years to evolve humans, so the present visible universe must be at least as large as the distance light travels in that time. The very enormity of our universe, which seems at first to signify how unimportant we are in the cosmic scheme, is actually entailed by our existence! The expanse of space is not an extravagant superfluity, it's a consequence of the prolonged chain of events, extending back before our solar system formed, that preceded our arrival on the scene.

The basic forces — themselves imprinted on the universe during its formative moments — have strengths that are specially tuned. Moreover, the Big Bang itself was seemingly given a well-tuned impetus. Otherwise, it would have dispersed too fast to allow galaxies and stars to form, or it would have collapsed to a premature Big Crunch, stifling any evolution before it had begun. This requires two other numbers to assume rather special values.

A further cosmic number controls the special texture of our universe. In a very broad-brush sense, matter is distributed uniformly. But at finer scales the universe is pervaded by galaxies containing billions of stars surrounding immense voids. Were the universe absolutely smooth, it would remain amorphous, cold gas — with no galaxies, no stars, no planets, and no people. But if it were too rough, it would be a violent realm, with no long-lived stars or stable planets.

Coincidence, Providence, or Multiverse?

There are various ways of reacting to the apparent tuning of these crucial numbers. One hard-headed response is that we couldn't exist without it: We are here, so there's nothing to be surprised about. Many scientists take this line, but it leaves me unsatisfied. I'm impressed by the analogy given by Canadian philosopher John Leslie. Suppose you are facing a firing squad. Fifty marksmen take aim, but they all miss. If they hadn't all missed, you wouldn't have survived to ponder the matter. But you wouldn't just leave it at that — you'd still seek some reason for your good luck.

Some attribute the tuning to a beneficent Creator. John Polkinghorne, a theologian who is also a distinguished physicist, writes that the universe is "not just 'any old world,' but it's special and finely tuned for life because it is the creation

of a Creator who wills that it should be so." This recalls the famous argument expounded by the theologian William Paley 200 years ago that a seemingly designed world implies a Designer, just as a watch implies a watchmaker.

But I prefer another analogy — not with a watch and its maker, but with a shop selling clothes off the rack. When there's a large stock at a shop we're not surprised to find some suits that fit us. Likewise, perhaps our Big Bang wasn't the only one. There might have been a varied assortment of Big Bangs, where the six numbers acquire different values. There would be no reason to be surprised at the tuning — no evidence of design. We could only have emerged (and therefore naturally now find ourselves) in a universe with the right combination of variables. This offers a radically new perspective on the tuning.

Science or Metaphysics?

A few years ago this concept could have been dismissed as metaphysics (a damning put-down from a physicist's viewpoint). It's hard to imagine anything more extravagant than postulating an infinity of universes disjoint from our own. But I think the concept now lies within the province of science. It is, of course, highly speculative. Still, cosmology has advanced enough that we know which questions must be addressed in order to firm it up.

According to one cosmological theory, known as eternal inflation, our colossal universe — which itself may extend much farther than any telescope can probe — may not be everything there is. Our Big Bang may be just one episode in an infinite ensemble. Other universes could be governed by different numbers. Most would be devoid of life because they recollapsed after a brief existence, or because the laws governing them didn't permit complex evolution. There are variants on these ideas in which new Big Bangs, triggered within black holes, sprout into domains of space and time disconnected from our own.

The six numbers are imprinted in the very earliest stages after the Big Bang — not the first few seconds (where we already have an adequate theory) but the first tiny fraction of a microsecond. Everything at that time was squeezed into a fireball far denser and hotter than anything we can simulate in the lab, so experiments offer little guidance. To bolster (or perhaps refute) the multiverse hypothesis requires a new synthesis between the best theories we now have — Einstein's theory of gravity and the quantum theories that govern the microworld. The most promising theory envisages subnuclear particles — and space itself — as vibrations or harmonies of tiny loops known as strings. These theories determine the structure of space itself — and a three-dimensional space seems essential for life — and the nature of the forces and particles.

As this infrared mosaic of the galactic center demonstrates, our universe provides many possible habitats for life. But our universe may be one of the few universes in which life is even possible.

2MASS, University of Massachusetts, IPAC (Caltech), Eugene Kopan

We still haven't probed the laws that govern nature at its very deepest level. A theory that has only exotic and untestable consequences would obviously not be taken seriously. But the multiverse concept may be a consequence of a theory that can be tested in other ways — one that, for instance, offers new insight into the forces and particles that govern the everyday world. Such a theory might then acquire enough credibility that we'd take seriously its predictions about other Big Bangs.

Are there an infinity of other universes that are badly tuned and therefore sterile? Is our entire universe an oasis in some still grander construct — a multiverse? Or should we seek other reasons for the seemingly providential values of our six numbers? ■

Cambridge University astrophysicist Sir Martin Rees is England's Astronomer Royal. Rees is author of Gravity's Fatal Attraction: Black Holes in the Universe *(with Mitchell Begelman),* Before the Beginning, *and* Just Six Numbers.

Summer's Brightest Visitor

Comet LINEAR could be the hit of the observing season.

by Richard Talcott

After a three-year lull, comet observing is back in vogue this month with a predicted 4th-magnitude maximum display of Comet LINEAR as its streaks through Ursa Major and Leo. Although LINEAR probably won't match Hyakutake's 2nd magnitude display in 1996, it should be the first comet visible to the naked eye since Hale-Bopp's magnitude –2 show in 1997. LINEAR (C/1999 S4) glows brightest in July and appears well above the horizon in the Northern Hemisphere. The comet's name does not imply it follows a straight path — LINEAR is an acronym for the discovery project, Lincoln Laboratory Near-Earth Asteroid Research. The LINEAR team, composed of MIT astronomers, uses a pair of state-of-the-art, 39-inch robotic telescopes to search for near-Earth asteroids as faint as 19th magnitude. The team has picked up dozens of asteroids and comets, including C/1999 S4. The comet reaches its closest point to Earth on July 22, three days before its closest approach to the sun. These factors combine to make the comet's appearance a relatively brief but eventful one.

Just how beautiful, however, astronomers can't say. This is LINEAR's first trip through the inner solar system from the icebox of the distant Oort Cloud. And predicting just how bright a first-time comet will become is fraught with uncertainty.

The problem: Most new comets have a surface frost of volatile ices, such as carbon monoxide. Warmed by the distant sun, this thin film begins to evaporate — fueling a rise in brightness. However, the amount of water ice in the cometary nucleus is the key factor influencing a comet's brightness as it nears Earth. Comet Kohoutek demonstrated the pitfalls in predicting a new comet's brightness. Touted in 1973 as the comet of the century, astronomers predicted it could get as bright as the full moon. Actually, it struggled to reach naked-eye visibility in early 1974. The brightness prognosticators fell silent until Halley returned to view in 1986.

A SLOW START

After spending April and much of May lost in the sun's glare, LINEAR pokes above the northeastern horizon before dawn in late May. It then meanders through the small constellation Triangulum. During the first week of June, it lies about 15° high as morning twilight commences and is expected to glow around 9th magnitude. At that time, binoculars should reveal the comet as a faint smudge. A small telescope will afford a better view.

The smudge does not represent the comet's nucleus — the dirty snowball from which all the activity arises. The nucleus is only a mile or so in diameter, far too small to be seen even with the Hubble Space Telescope. As sunlight warms the nucleus, the ices turn directly to hissing gas, liberating both gas and dust in the process. The smudge, called the coma, is the huge cloud of gas and dust surrounding the nucleus.

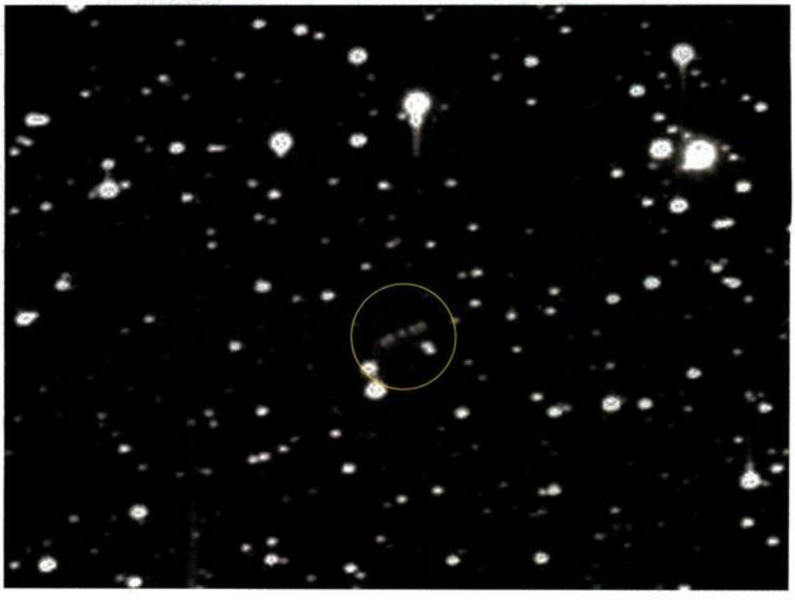
The pressure of sunlight gently pushes the coma's dust particles away from its coma, forming the dust tail. Solar ultraviolet radiation, on the other hand, strips electrons from the gas molecules, creating ions. Then the magnetic field carried along by the solar wind picks up the ionized molecules and creates a second tail. The tails point away from the sun, which is bad news in early June when we view the comet nearly head-on (and the tail is obscured by the coma).

However, our viewing angle improves with time. During June Comet LINEAR moves slowly to the northeast, crossing Triangulum and pushing into eastern Andromeda. It brightens and climbs higher above the northeastern horizon before dawn of each passing day. By July 1 it may be up to 7th magnitude, still too faint to see with the naked eye but an easy target in binoculars. July 1 also offers one of the best conjunctions of the comet's apparition. On that morning LINEAR lies less than 2° northwest of the bright open star cluster M34. With the moon reaching new phase, there will be little lunar light to spoil the view.

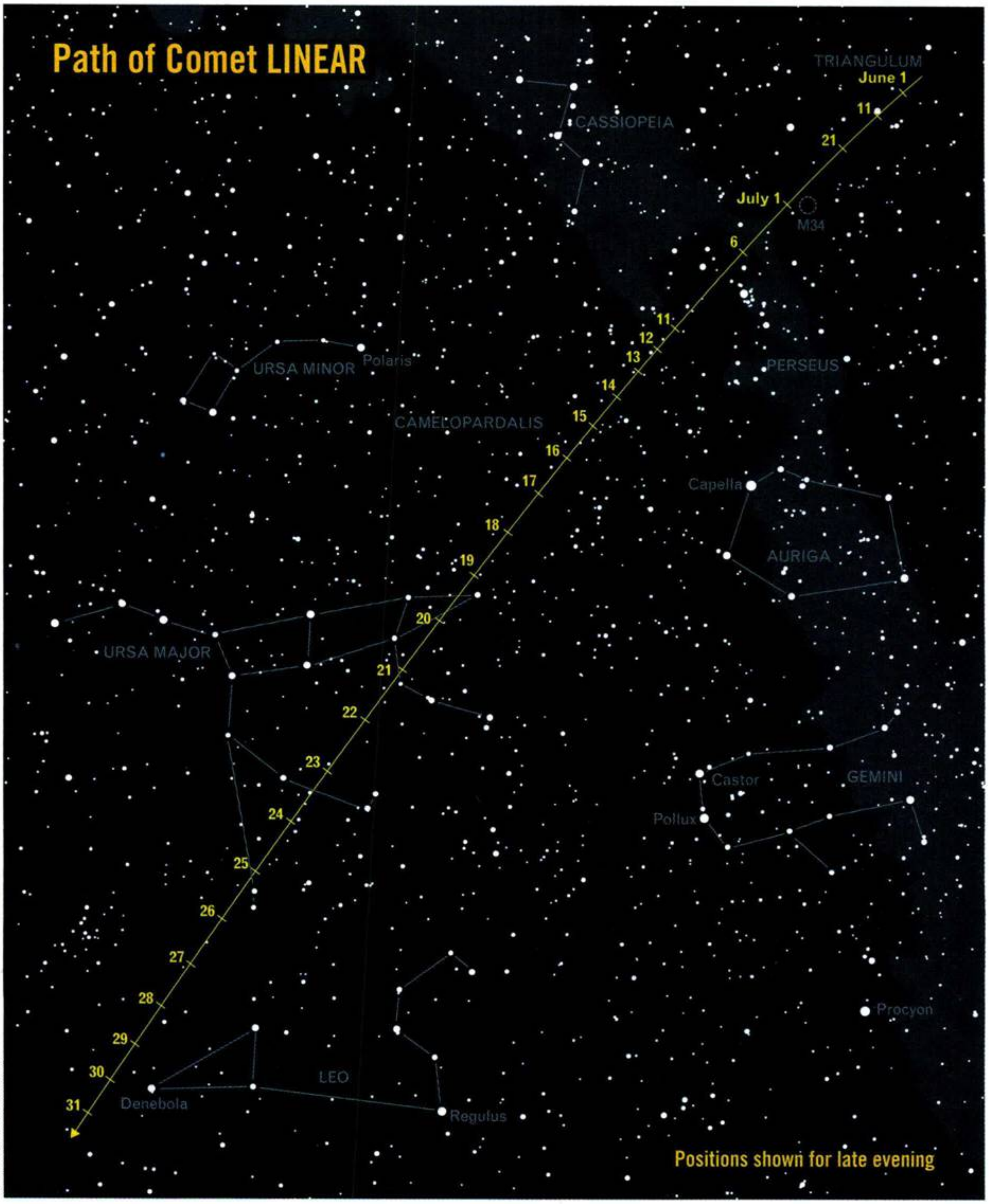
A FAST FINISH

The comet will pick up speed, crossing into Perseus during the first week of July and traversing the thin spine of the Milky Way. By July 11 LINEAR will push into Camelopardalis — a large, faint constellation that provides a good backdrop for spotting the comet.

The comet's motion will be mostly eastward, and it will lie far enough north in the sky (at a declination of about 60°) that it is visible all night. The best view will come in the morning, when it climbs to an altitude of more than 30° by the beginning of dawn. Although the moon will be full on July 16, it will be a slight hin-



Previous page: LINEAR hit magnitude 13.8 on February 23, 2000. Tim Puckett
Right: Five images taken September 27, 1999, at 20-minute intervals and superimposed revealed a magnitude 15.8 comet. Lincoln Laboratory



Path of Comet LINEAR

TRIANGULUM
June 1
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CASSIOPEIA
July 1
M34
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URSA MINOR
Polaris
CAMELOPARDALIS
Capella
AURIGA
URSA MAJOR
GEMINI
Castor
Pollux
Procyon
LEO
Denebola
Regulus
Positions shown for late evening

Astronomy: Elisabeth Rowan

drance, as the comet glows between 4th and 5th magnitudes.

By the time LINEAR reaches its closest approach to Earth on July 22 and its closest approach to the sun three days later, its eastward motion will make it a better evening object. That's good because the waning moon will leave the evening sky by then. On July 23 and 24, LINEAR will move rapidly southeast through Ursa Major, south of that constellation's Big Dipper asterism.

By the end of July, LINEAR will be racing south through Leo and sinking closer to the horizon at evening twilight. The view in August deteriorates, as the comet fades from naked-eye visibility and continues south, becoming harder for Northern Hemisphere observers to see. Yet if the apparition goes as planned, those observers will look back fondly on the brief summer show.

Richard Talcott is a comet enthusiast and Astronomy *associate editor.*

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sky Show

july

Tackle Triton, Vesta, and Comet LINEAR during warm evenings.

by Martin Ratcliffe and Alister Ling

▶You don't even need a telescope to watch the major sky events this month. Make a point to rise before dawn. Your reward will be the sight of Comet LINEAR (c/1999 S4) continually brightening toward its peak later this month. Use binoculars to see it pass the star cluster M34 on the last night of June. LINEAR then leaps nightly in large steps across the north into the late evening sky by the 20th. With luck, it will be brighter than its predicted maximum of magnitude 3.5. It's almost gone by August 1, so don't procrastinate or you'll miss it. LINEAR is the first naked-eye comet to appear since Hale-Bopp, some three years ago.

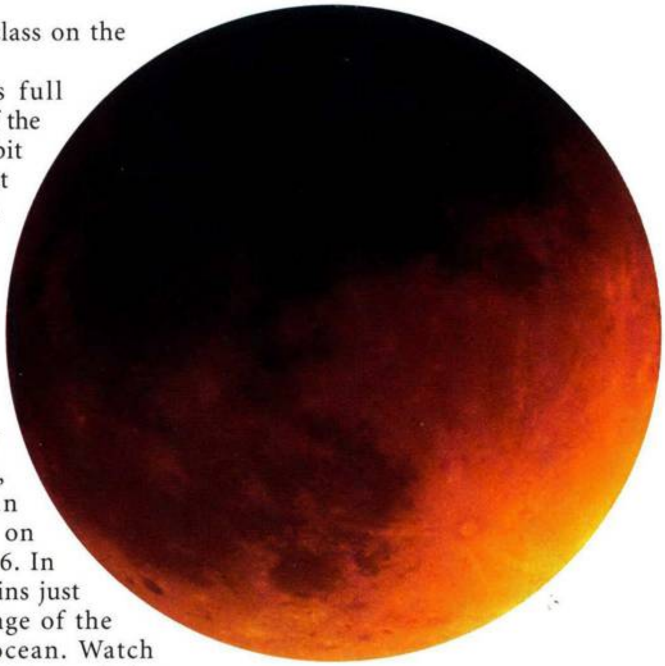
Many picture-perfect opportunities await you in dawn skies. Jupiter and Saturn shine prominently between the beautiful Pleiades and Hyades star clusters. Simply put your camera on a tripod, use slow color film, no faster than ISO 100, and take a range of exposures of ½ to 10 seconds. Fine-grain film is best for making enlargements of your successes. The beautiful crescent moon adds a dash of class on the morning of the 26th.

While waiting for the 4th of July fireworks, point out stars to friends. David Johnson

Does this month's full moon, on the evening of the 15th and 16th, look a bit petite? It is the smallest of the year, more than a 10-percent reduction in size compared to last winter's large solstice moon.

If you live along the west coast of North America, treat yourself to an unusual eclipse of the moon at moonset, which occurs just an instant before sunrise on the morning of July 16. In California, totality begins just after the remnant fringe of the moon sets into the ocean. Watch Earth's shadow reach out to touch the face of the moon.

Two weeks after the lunar eclipse, the moon slowly slices across the sun's blinding disk, producing a partial eclipse of the sun during the early evening of Sunday, July 30. Don't look at the sun even if haze dims its disk. All light waves, including the harmful but invisible ultraviolet and infrared rays, need proper filtering.



Observers in the west get to see a second lunar eclipse this year. Del Gebhardt Jr.

For a unique observing experience that takes a little more effort, try to spot an asteroid. Many novice astronomers have yet to view one. Vesta, the fourth minor planet to be discovered, is so bright this month that from country skies you can follow its motion with unaided eyes. It's also big enough that, under superb conditions, a 16-inch scope will reveal the tiny disk of Vesta.

Experts in the northwest of the continent can push their skills to the limit. For a few minutes, the moon will occult the two inner planets in daylight. The invisibly thin old crescent moon covers Mercury in the morning hours of July 29, while the equally invisible young crescent covers Venus on the early evening of the 31st.

July 2000

1 Mars is in conjunction with the sun, noon EDT
New moon is at 3:20 P.M. EDT; partial solar eclipse (page 72)
The moon is at perigee (222,055 miles from Earth), 6:17 P.M. EDT

3 Earth is at aphelion (94.5 million miles from the sun), 8 P.M. EDT

6 Mercury is in inferior conjunction, 8 A.M. EDT

8 First quarter moon is at 8:53 A.M. EDT

15 The moon is at apogee (252,401 miles from Earth), 11:34 A.M. EDT

16 Full moon is at 9:55 A.M. EDT; total lunar eclipse (page 72)
Asteroid Vesta is at opposition, 2 P.M. EDT (page 73)

24 Last quarter moon is at 7:02 A.M. EDT

25 Comet LINEAR is at perihelion (71.1 million miles from the sun), midnight EDT (page 73)

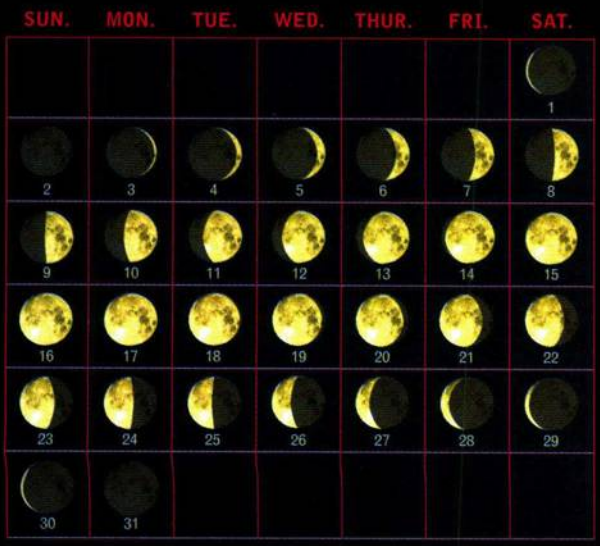
26 The moon passes 2° south of Saturn, 5 A.M. EDT
The moon passes 3° south of Jupiter, 4 P.M. EDT

27 Mercury is at greatest western elongation (20°), 5 A.M. EDT
Neptune is at opposition, 7 P.M. EDT (page 71)

28 Southern Delta Aquarid meteor shower peaks (page 72)

29 The moon passes 0.8° north of Mercury, 1 P.M. EDT (page 71)

30 The moon is at perigee (222,684 miles from Earth), 3:45 A.M. EDT
Asteroid Flora is at opposition, 7 P.M. EDT
New moon is at 10:25 P.M. EDT; partial solar eclipse (page 72)


SUN.
MON.
TUE.
WED.
THUR.
FRI.
SAT.
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2
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4
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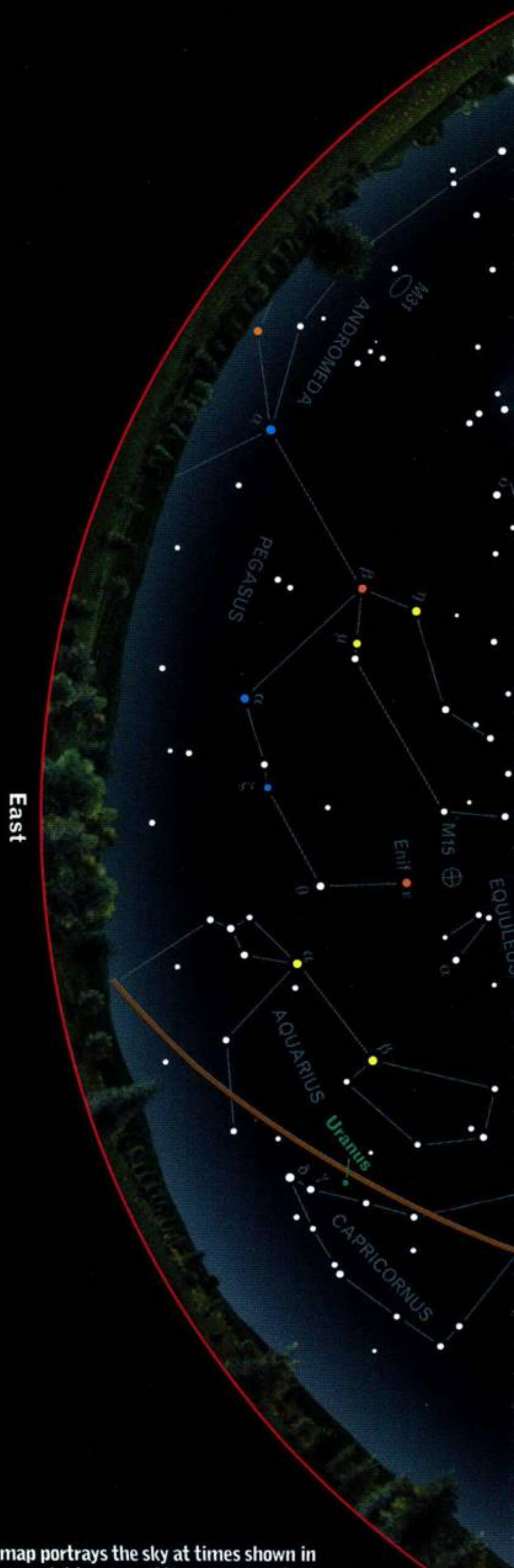
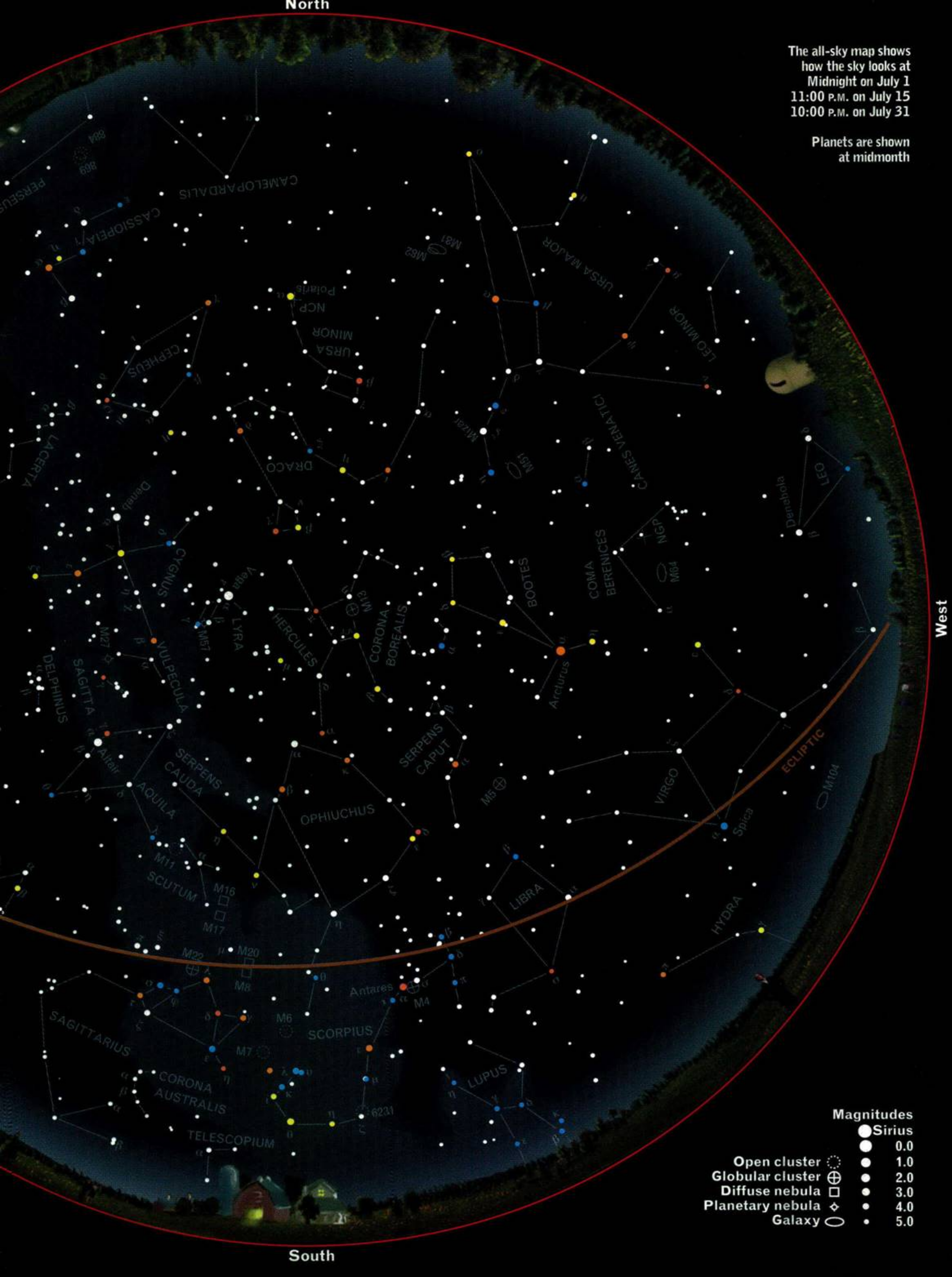
31


ANDROMEDA
M31
PEGASUS
Enif
M15
EQUULEUS
East
AQUARIUS
Uranus
CAPRICORNUS

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

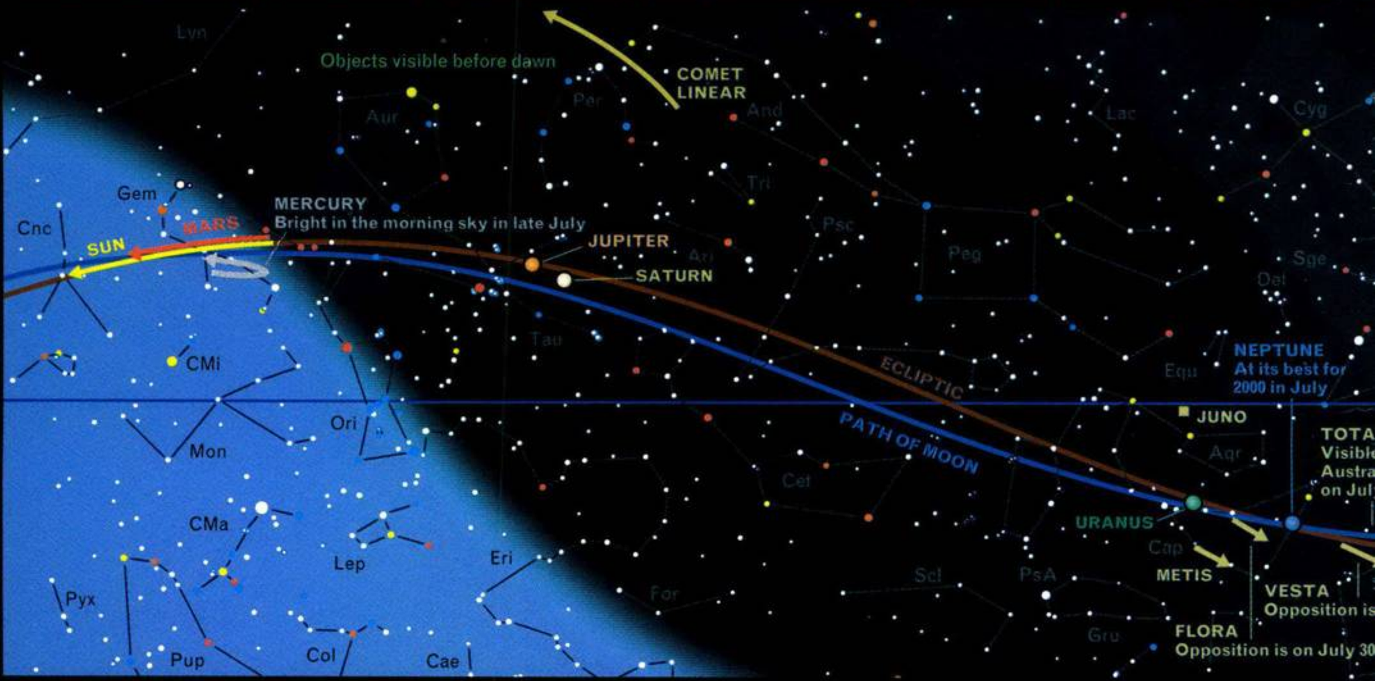

North
South
West
CAMELOPARDALIS
CASSIOPEIA
PERSEUS
869
884
M81
M82
URSA MAJOR
Polaris
NCP
URSA MINOR
LEO MINOR
CEPHEUS
LACERTA
DRACO
Mizar
M51
CANES VENATICI
LEO
Denebola
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Arcturus
M27
VULPECULA
SAGITTA
DELPHINUS
Altair
AQUILA
SERPENS CAUDA
SERPENS CAPUT
M5
OPHIUCHUS
VIRGO
Spica
ECLIPTIC
M104
M11
SCUTUM
M16
M17
LIBRA
HYDRA
M22
M20
M8
Antares
M4
M6
SCORPIUS
M7
SAGITTARIUS
CORONA AUSTRALIS
LUPUS
6231
TELESCOPIUM
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
Midnight on July 1
11:00 P.M. on July 15
10:00 P.M. on July 31

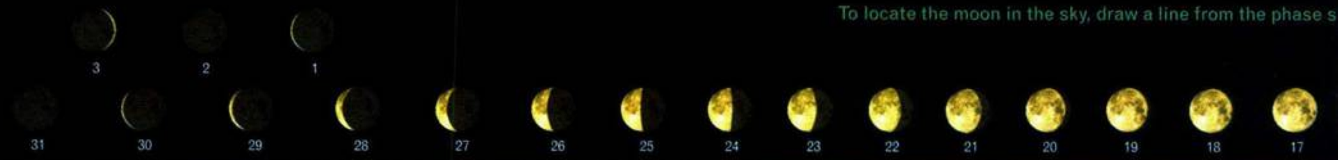
Planets are shown
at midmonth

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects


Lyn
Objects visible before dawn
COMET LINEAR
Per
And
Aur
Lac
Cyg
Gem
Tri
Cnc
MERCURY
Bright in the morning sky in late July
MARS
SUN
JUPITER
SATURN
Psc
Ari
Peg
Sge
Del
Tau
CMi
ECLIPTIC
NEPTUNE
At its best for 2000 in July
Equ
Ori
JUNO
PATH OF MOON
TOTA
Visibl
Austra
on Jul
Mon
Cet
Aqr
URANUS
CMa
Cap
Lep
Eri
METIS
VESTA
Opposition is
Pyx
Scl
PsA
For
FLORA
Opposition is on July 30
Gru
Pup
Col
Cae

To locate the moon in the sky, draw a line from the phase s


3
2
1
31
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29
28
27
26
25
24
23
22
21
20
19
18
17

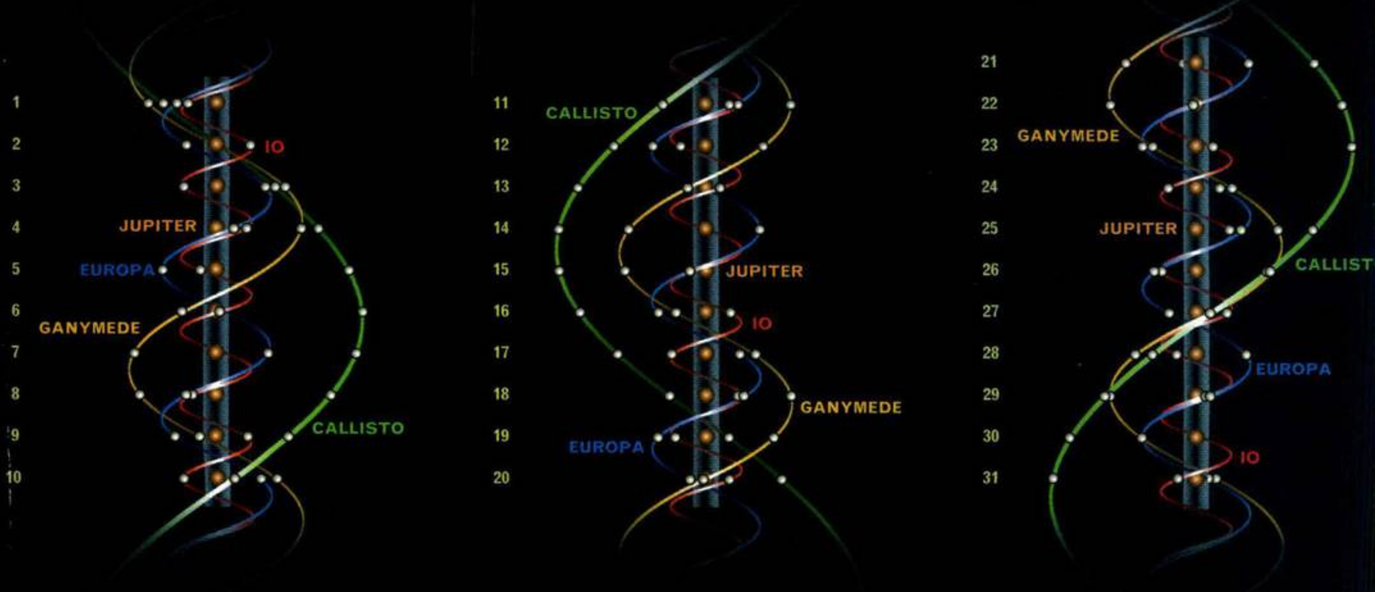
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPIT
Date	July 15	July 31	July 31	July 15	July
Magnitude	2.8	−0.2	−3.9	1.6	−2.1
Angular Size	10.6"	7.0"	10.0"	3.6"	35.2
Illumination	8%	51%	97%	100%	99%
Distance (AU) from Earth	0.636	0.963	1.664	2.620	5.59
Distance (AU) from Sun	0.422	0.334	0.719	1.608	5.00
Right Ascension (2000.0)	6h44.9m	7h21.2m	9h38.3m	7h22.4m	4h04.3
Declination (2000.0)	18°25'	20°57'	15°39'	23°03'	19°5

10"

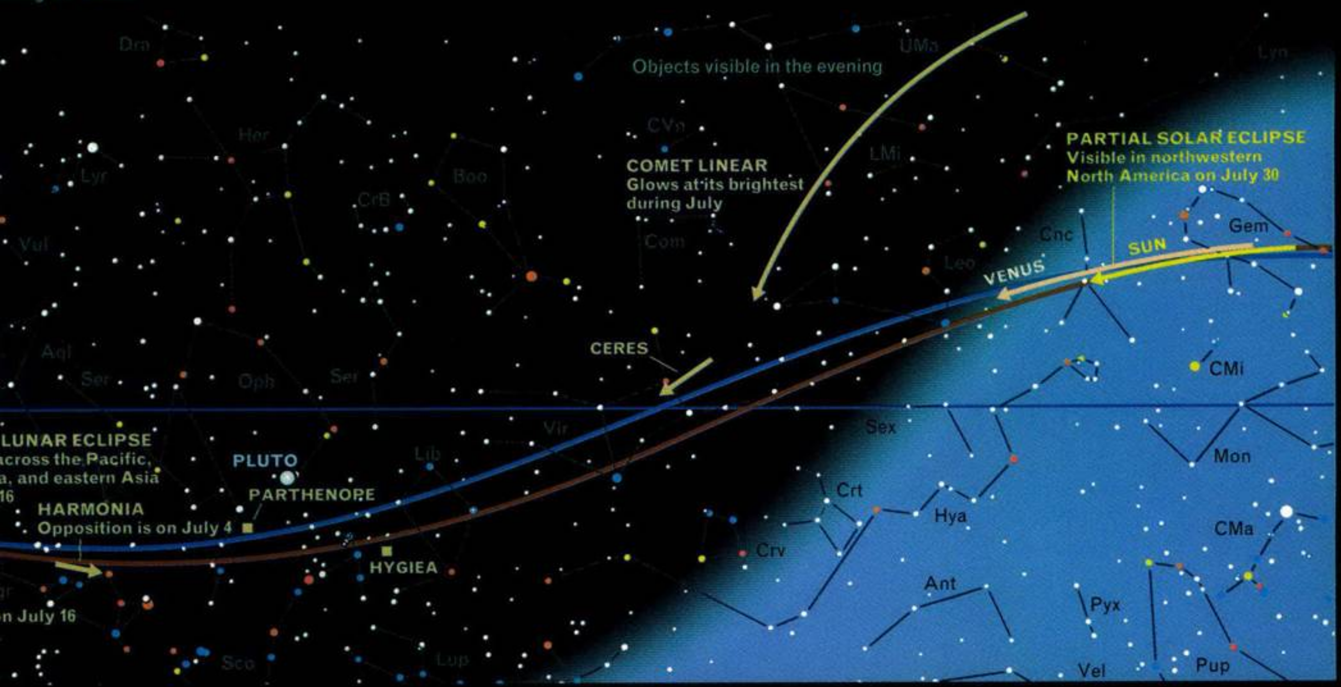
S W E N

Jupiter's Moons

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view in a telescope.



uring the month.


Dra
UMa
Lyn
Her
CVn
LMi
Lyr
Boo
CrB
Gem
Vul
Com
Cnc
SUN
VENUS
Leo
Aql
Ser
Oph
Ser
CERES
CMi
Vir
Sex
Lib
Mon
PLUTO
PARTHENOPE
Crt
Hya
CMa
HYGIEA
Crv
Ant
Pyx
Sco
Lup
Vel
Pup

Objects visible in the evening

COMET LINEAR
Glows at its brightest
during July

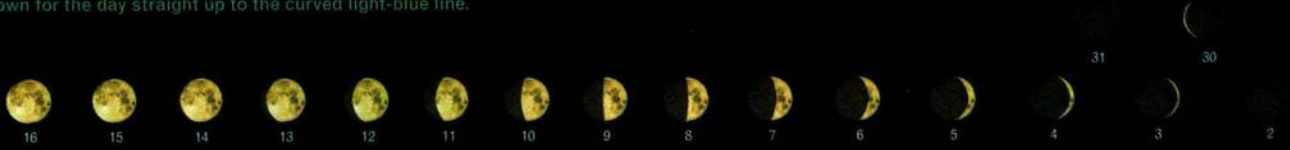
PARTIAL SOLAR ECLIPSE
Visible in northwestern
North America on July 30

LUNAR ECLIPSE
across the Pacific,
a, and eastern Asia
16

HARMONIA
Opposition is on July 4

n July 16

own for the day straight up to the curved light-blue line.


31
30
16
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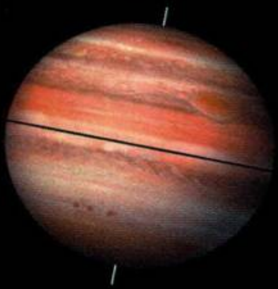
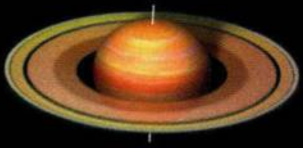
7
6
5
4
3
2

R

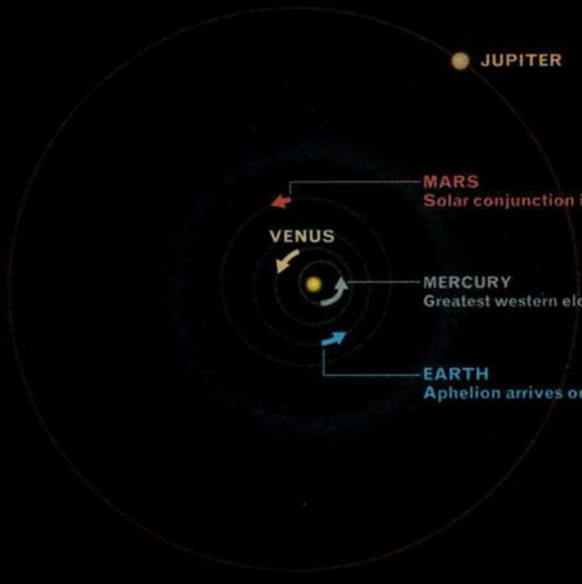




SATURN	URANUS	NEPTUNE	PLUTO
July 15	July 15	July 15	July 15
0.2	5.7	7.8	13.8
17.1"	3.7"	2.3"	0.1"
100%	100%	100%	100%
9.692	19.032	29.121	29.538
9.144	19.943	30.114	30.283
3h45.0m	21h30.1m	20h31.3m	16h42.0m
17°44'	–15°33'	–18°41'	–10°59'

The Planets in Their Orbits

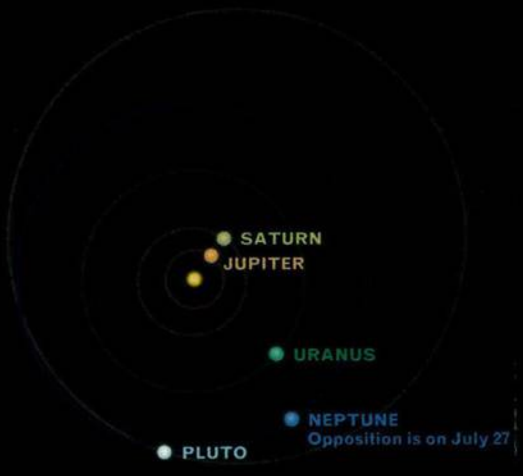
Arrows and dots show planets' positions during the month.


JUPITER
MARS
VENUS
MERCURY
EARTH

MARS
Solar conjunction is on July 1

MERCURY
Greatest western elongation is on July 27

EARTH
Aphelion arrives on July 3/4


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

NEPTUNE
Opposition is on July 27

A Grand Globular in Sagittarius

Bright globular star clusters simply exude magnificence. These assemblages of hundreds of thousands of old stars float in long elliptical paths around the galaxy and elicit sighs from observers.

A small telescope easily shows dozens of individual stars sparkling over a large, bright round haze that makes up M22 in Sagittarius. Put a 10- or 20-inch scope on this patch, the third brightest globular in the heavens, and suddenly thousands of individual stars pop into sight. For the ultimate view, head out under a dark sky, at new moon, during the first or last nights of the month.

To find M22, simply jump to the bright star at the "lid of the teapot." Small binoculars or a 30mm finderscope readily shows a large glow about half a field to the upper left (northeast) of Lambda (λ) Sgr. At magnitude 5.1, you can catch M22 with your unaided eyes as a hazy "star."

Its brightest stars shine a whole magnitude brighter than those in the famous cluster Omega (ω) Centauri, which dominates Southern Hemisphere skies. This means that M22 will deliver through city lights. Crank up the power for an impressive view.

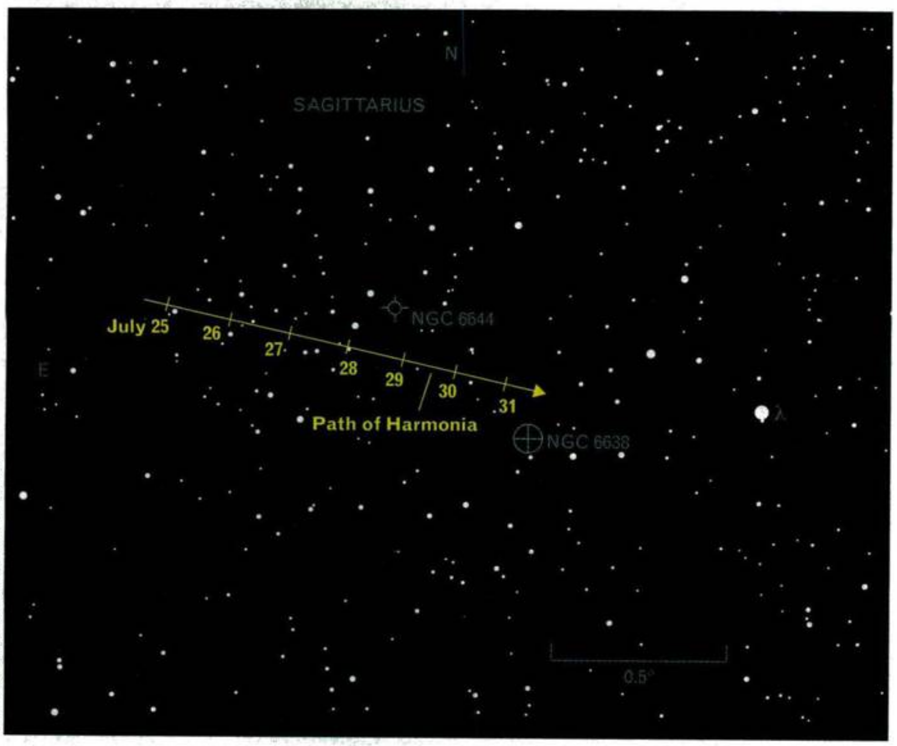
Nearby lies a cousin, M28, twice as close to Lambda Sgr. M28 is considerably different, not counting the fact it is half the size of M22. It shows more concentration to the middle and is tougher to split into stars, even though its total magnitude is 6.8. Its brightest stars glow at 12th magnitude, which are in reach of a 4-inch scope in dark skies. To resolve the cluster into hundreds of distant supergiants, you'll need a 16-inch scope.

Three-in-One

You can catch an asteroid, globular cluster, and planetary nebula in one field of view this month. Closer yet to Lambda Sgr hides a small globular, NGC 6638. If you saw Comet LINEAR through the telescope back in April, at magnitude 9.2 this fainter fuzzball is reminiscent of the comet at that time. Being twice as far from us as M22, NGC 6638 will reveal tantalizing glimpses of its brighter stars only to 16-inch telescopes or larger.

On July 31, minor planet 40 Harmonia floats just 10', one-third of a lunar diameter, north of NGC 6638. This 70-mile-wide (110-km) asteroid glows at magnitude 10.1, of similar brightness to several nearby stars. Use the chart to help pinpoint it.

The globular cluster M22 makes a great appearance in small telescopes. John Chumack



All illustrations: *Astronomy*/Elisabeth Rowan

Camouflaged by field stars a mere moonwidth to the northeast of NGC 6638 is the small planetary nebula NGC 6644. Planetaries are the dying remnants of middleweight stars, puffed-out cocoons of fluorescing gas. This one resembles Neptune, although quite a bit fainter at magnitude 11.5. NGC 6644 is within the grasp of an 8-inch telescope.

Employ a high-tech trick used by many deep-sky observers. Use a nebular filter to "blink" this 3" planetary. Simply take a filter and move it back and forth between your eye and the eyepiece. You should see a star "winking" back at you. Much of the nebula's light is emitted as ionized oxygen, or OIII, and passes through the filter. The background sky, however, goes dark, and most stars fade considerably through the filter. When you slide the filter in front of the eyepiece, the nebula becomes the bright object, "blinking" into view.

sky Show

The Planets Parade at Dawn

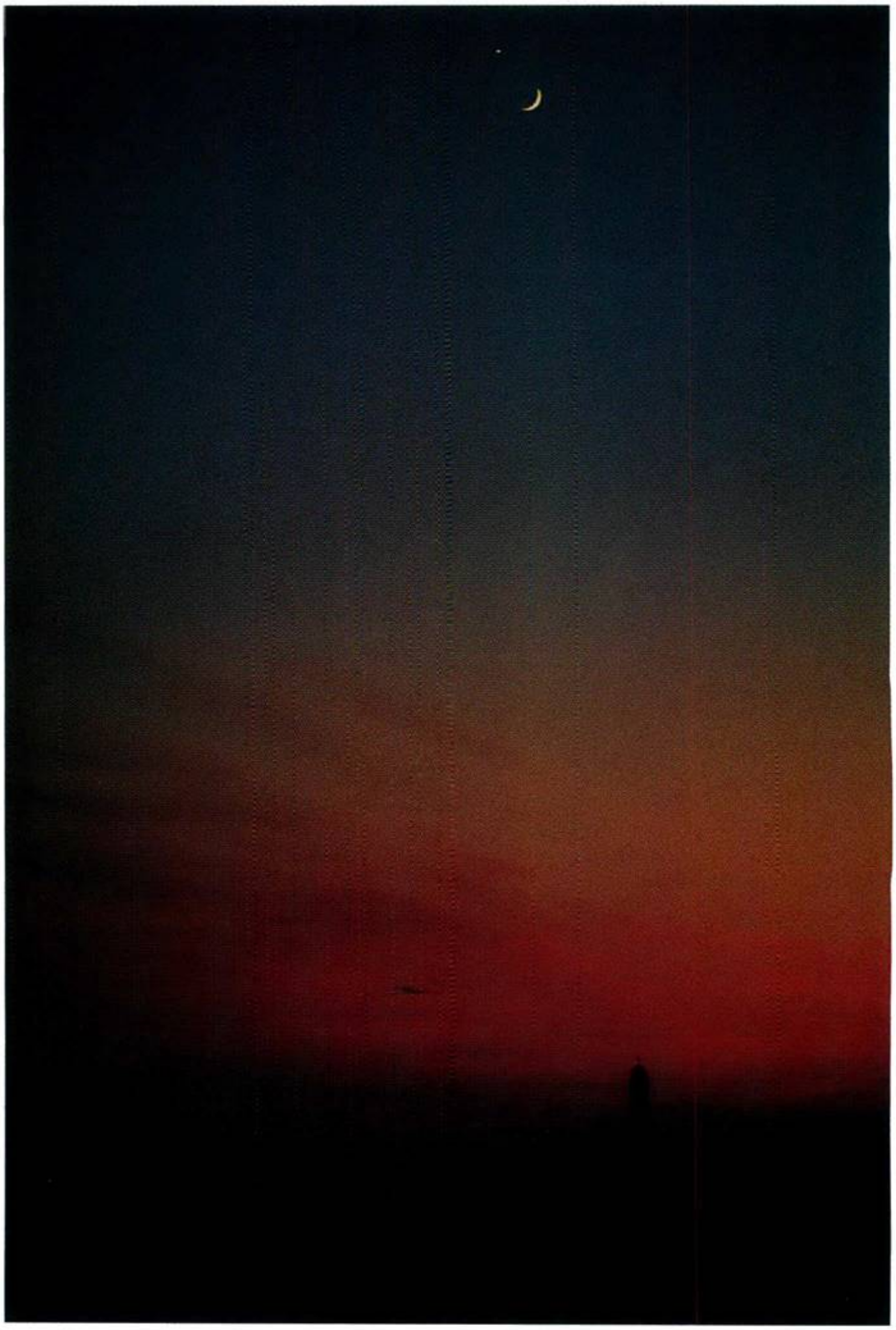
You'll have to wait until the last week of July to spot a naked-eye planet in the evening sky. **Venus** begins its "Evening Star" performance when the crescent moon joins in for an opening duet on July 31. Find a clear western horizon to spot the slender crescent moon, just one day past new, lying within a moon-width of Venus. In the bright summer twilight, the rapidly twinkling Venus shines at magnitude –3.9. In contrast to our moon, Venus exhibits an almost full phase when viewed through a telescope. This phase tells us that Venus presently lies on the far side of the sun.

From the brightest planet to the faintest — **Pluto** lingers within a degree of Zeta (ζ) Ophiuchi during July. Glowing faintly at magnitude 13.8, Pluto is a hard planet to spot, even with an 8-inch telescope. Catching sight of the solar system's ninth planet requires the most clear, transparent, and moonless night.

Much easier to spot is **Neptune**, which reaches opposition on July 27, placing this date smack in the middle of the best time to view the distant planet. Still, it's so far away that its reflected light takes four hours to reach us on Earth. Neptune, a binocular object if you know what you're looking for, lies among the stars of western Capricornus the Sea Goat. This month it is easier to spot than usual. Try searching near the magnitude 6.7 star Omicron (ο) Capricorni. Two brighter stars make Omicron an easy find — since Pi (π) and Rho (ρ) Capricorni form the base of a triangle with Omicron at its apex. Neptune remains within 0.5° of Omicron for the entire month and passes within 10' of it on July 28. Watch it slowly glide by throughout the month. Even at a dim magnitude 7.8, Neptune's close proximity to a brighter star will aid its identification.

Easier yet is **Uranus**, shining at magnitude 5.7. Still a few weeks away from opposition, Uranus is bright enough to be spotted with the unaided eye when attempted from dark locations. Look for the 3.7-magnitude star Gamma (γ) Capricorni and 4.3-magnitude Iota (ι) Capricorni toward the eastern edge of Capricornus. Uranus lies at the apex of a triangle where Gamma and Iota form the base. Through a scope you can spot the 3.7"-diameter disk with its bluish-green color.

By dawn on July 31, the brilliant pair of planets, **Jupiter** and **Saturn**, stand high above the southeastern horizon. They rise at 2 A.M. local time. Jupiter and Saturn continue to pull away from each other as seen from our vantage point on Earth. Last month a coincidental line of sight placed both planets within the same telescopic field of view — now in July, more than 4° separate the pair. The distance between them slowly widens each day. The drama of the pairing is greatly enhanced by two



Venus and the crescent moon make a pretty pairing at sunset. Spiridon Caragiogos

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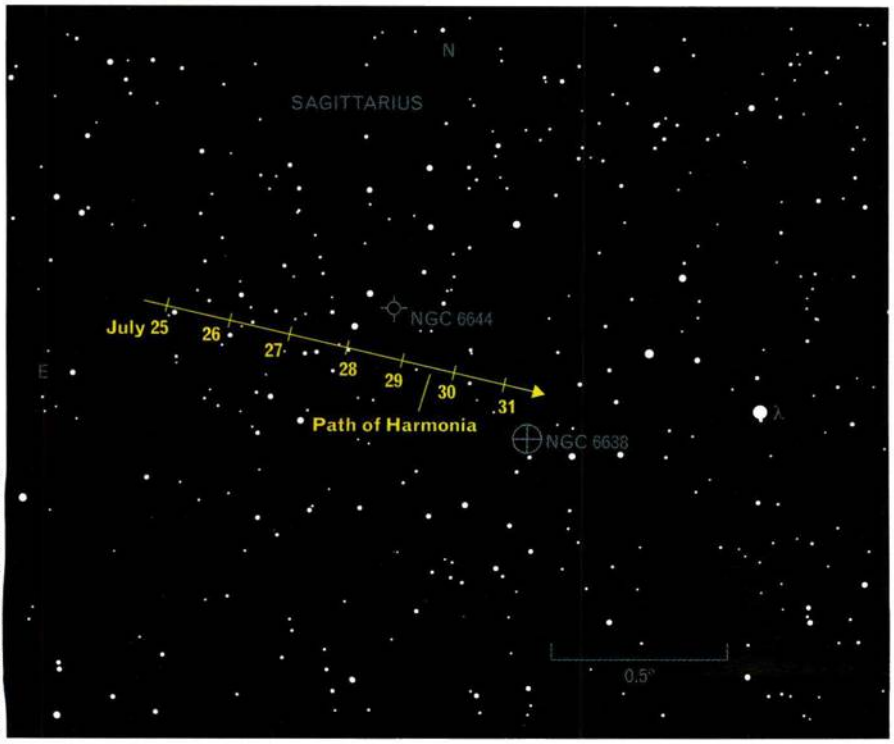

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Meteors and Moons

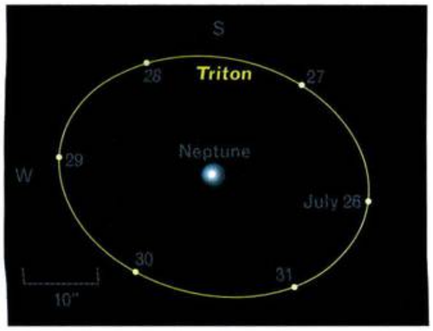
Three Eclipses in One Month

Three eclipses occur this month, two solar and one lunar. A partial solar eclipse, visible from southernmost South America, occurs on July 1. On July 30–31 another partial solar eclipse straddles the International Date Line and is visible from the Arctic Circle, including the northern half of Alaska and the northwestern United States. For Alaskans, the eclipse begins late in the afternoon of July 30. For observers in Anchorage, mideclipse occurs at 5:49 P.M. local time.

The total lunar eclipse at dawn on July 16 is one of the longest, because the moon cuts centrally through the shadow of Earth. It is visible from Hawaii, Australia, Japan, China, and Indonesia. Eclipses occur when a full or new moon is at or near one of the nodes — crossing points of the moon's orbit with the ecliptic. For this month's lunar eclipse, the full moon occurs within 30 minutes of the moon being at the node. The moon is also at apogee, meaning its farthest point from Earth — so its somewhat slower orbital motion makes for one of the longest lunar eclipses for over a century — 1 hour and 46 minutes. The next lunar eclipse that lasts this long occurs on June 9, 2123.

Extraterrestrial Moons

If you had no trouble spotting Pluto this month, you might try a real challenge and view Neptune's largest moon, Triton. With Neptune at opposition, this is the best time of year to spot magnitude 14.0 Triton. On July 28–29 Triton will appear south of the planet, and by July 31 it will lie to the north.

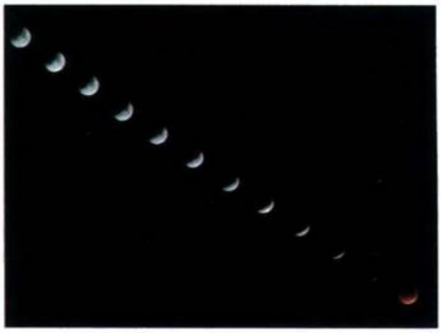


Easier moons to spot are Jupiter's four Galilean moons. These moons frequently traverse the disk of Jupiter or become blocked out by it. Io is the most frequent participant because it orbits the planet in 1.8 days — though not all events are visible while Jupiter is above the horizon. Predictions of these events can now be calculated using many computer software programs and are published in the *Astronomical Almanac* every year.

Meteors at Midnight

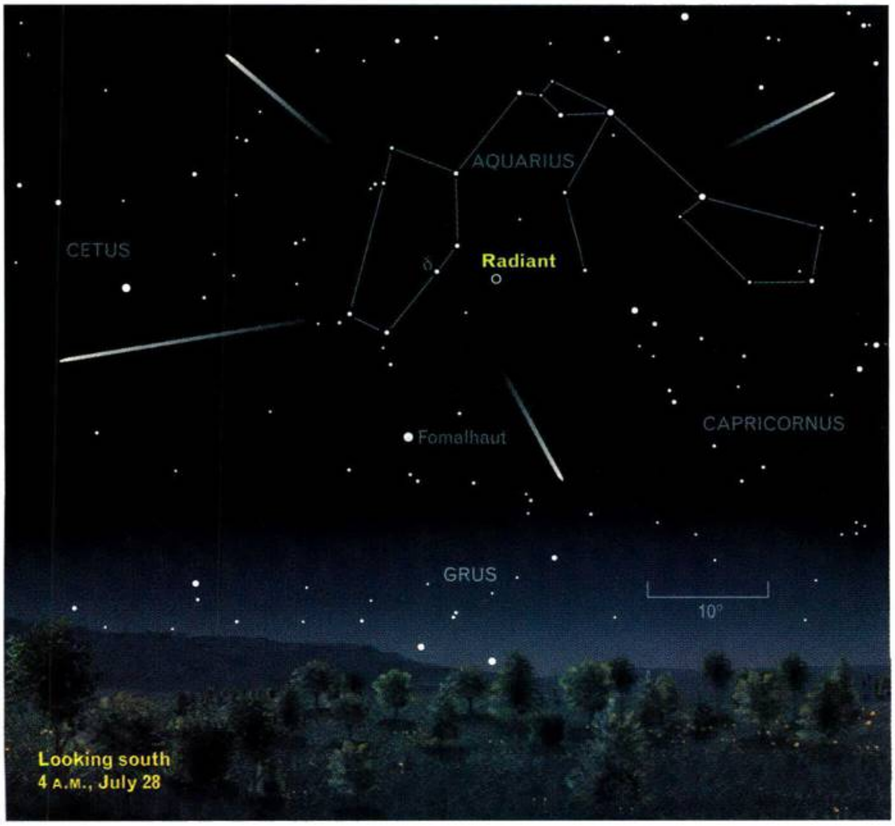
The neighboring constellations Aquarius and Capricornus rise above the eastern horizon by midnight in July and host meteor showers this month.

The Southern Delta Aquarids are active between July 12 and August 19. The waning crescent moon toward the end of the month will aid viewing, and the zenithal hourly rate (the number of meteors an hour seen if the radiant were overhead) is 20. Meteors from this shower are fairly swift, with typical speeds of 25 miles per second peaking around the end of the month.



A lunar eclipse occurs just at moonset and dawn for West Coast observers. Bruce Elliott

The Alpha Capricornids are less reliable but active from July 3 to August 15. The low rate is offset by long trails due to the low elevation of the radiant. Northern observers see these meteors as they skim Earth's atmosphere at a relatively slow speed of 14 miles per second. The peak occurs over a weekend just before the July 31 new moon.



Looking south
4 A.M., July 28

Comet LINEAR Peaks

We have eagerly awaited our cometary target since first hearing about it almost a year ago. If predictions have come true, then Comet LINEAR (c/1999 S4) will now sit at the edge of naked-eye visibility, ready to brighten by a factor of 15 this month. Enjoy every minute of it, because by early August, it suddenly fades.

This dirty snowball of ice and dust starts out in the dawn sky to the northeast, then in just one month vaults across the north below Polaris into the western evening sky. It's worth one trip in July out to the countryside because you'll get your best views away from city lights (and with the moon below the horizon).

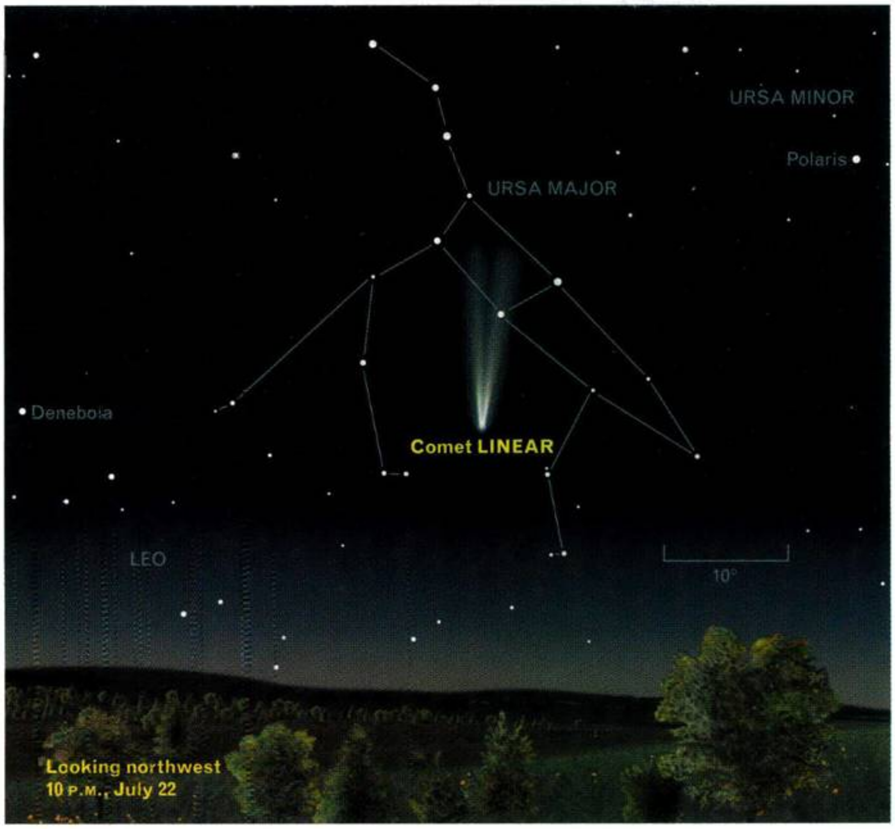
Start on June 29 or 30, at 3 A.M., when LINEAR will be a bright binocular object of about magnitude 6.3 near the splashy star cluster M34 in Perseus. Over the next two weeks, before the moon gets in the way, watch LINEAR's tail grow, pointing almost straight up away from the morning horizon.

By the 13th and 14th, in the hour between moonset and dawn, 4.5-magnitude LINEAR floats near the delightful binocular splash of stars called Kemble's Cascade. Try for some nice wide-field photos.

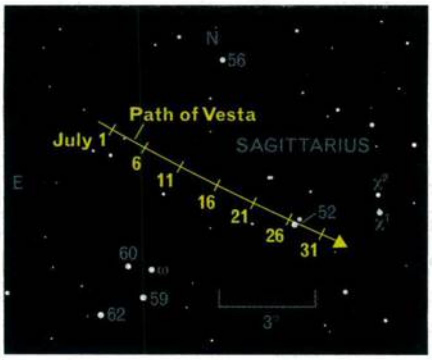
The prettiest views will be through binoculars and low-power telescopes. But to see fascinating structure in the tail and bright inner coma, crank it up past 150x. Use a dark cloth over your head to keep stray light at a minimum.

On July 19th the moon rises after 10:30 P.M. Every night thereafter it rises about an hour later. At this point, the comet should be near its peak brightness of about magnitude 3.5. LINEAR moves under Polaris and heads below the bowl of the Big Dipper.

During the last week of July, we're in a losing battle. Each evening the comet will be lower in the sky for a given time, washing out the tail. To see it any higher means to start earlier, but then the twilight is still bright.



Looking northwest
10 P.M., July 22



Comet LINEAR as photographed in March.

Tim Puckett

In the first week of August, LINEAR plunges southward and fades as the crescent moon rises and brightens.

Viewing Vesta without Optical Aid

While you're up in the wee hours checking out Comet LINEAR, turn around and face the southern sky, where 5.7-magnitude 4 Vesta is sliding across the dark expanse east of Sagittarius. Use the chart to pinpoint the 300-mile-wide (500-km) hunk of rock.

Relax and shade your eyes from any stray light. You may want to use binoculars first just to get your bearings.

On the weekend of the 28th, Vesta may be too close to the star 52 Sgr to see with the naked eye, but by Saturday night it could be just in reach, one moonwidth farther west. ◼

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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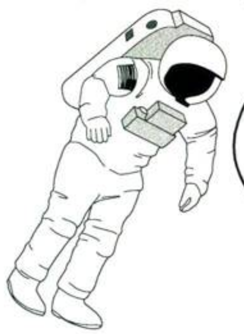

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18mm 1.25"	228	12mm 2"/1.25"	340
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ASTRONOMY BOOKS

The Deep Sky: An Introduction

By Philip S. Harrington Here is the perfect reference for anyone, who owns a telescope or a pair of binoculars but doesn't know what to look for amid the constellations. It explains how to find double and multiple stars, variable stars, open and gobular clusters, nebulae, and galaxies — what you'll see when you do.Includes 36 full-page sky charts, equipment, books, and software suggestions, sketches of how deep-sky objects look through a small telescope, and more than 100 black & white photographs. 272 pages.

The Deep Sky: An Introduction	24.95
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The Myst
Maria's Comet
Deborah Hopkinson
Deborah Lanino

Astronomy by the BOOK

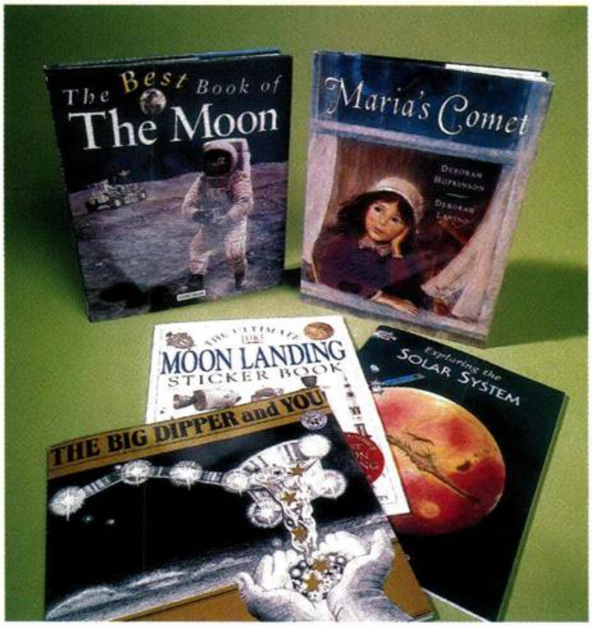
Share the universe with your child; crack open a good book.

by Kelly Kizer Whitt

"No more homework, no more books, no more teacher's dirty looks." If you have children, you've probably heard this tune sung lately as kids were released from school for the summer. But the beginning of vacation doesn't have to bring an end to learning. Many good books about astronomy are published each month, from stories for beginning readers to encyclopedias and skywatching guides for serious young adults. Summer reading can give your child a jump start on science or supplement his or her education, because, unfortunately, a majority of schools don't even include astronomy in their core curriculum.

The following books can get you and your kids started. All are sold at Amazon.com or BarnesandNoble.com or can be requested at your local library. I have divided them into three reading levels, children to age 8, ages 9 to 12, and teens and up.

READING LEVEL: AGES 4-8


The Best Book of The Moon
Maria's Comet
Deborah Hopkinson
Deborah Lanino
The Ultimate Moon Landing Sticker Book
The Big Dipper and You
Exploring the Solar System

Maria's Comet

Deborah Hopkinson and Deborah Lanino (Illustrator), 32 pages, Atheneum Books, New York, 1999; ISBN 0-689-81501-8; hardcover, $16.

If your children are still too young to read alone, *Maria's Comet* offers a great story to read to them. The book is filled with colorful drawings depicting a fictional account of little Maria's childhood. Maria Mitchell, America's first influential female astronomer, was the inspiration for the work. The back of the book holds a one-page description of the real Maria Mitchell and an explanation of terms used to help answer questions that your children may pose.

Exploring the Solar System

Bruce LaFontaine, 48 pages, Dover Publications, Mineola, New York, 1998; ISBN 0-486-40361-0; paperback, $2.95.

One sure way to get kids interested in something is to give them an activity. *Exploring the Solar System* is part of the Dover Coloring Book series. Packed with black-and-white line drawings on every page ranging from the planets to the faces of scientists to space probes, the book is sure to keep your child busy coloring for hours. Small print at the bottom of each page enlightens your little Picasso as to the significance of each drawing. The text requires an advanced reader. The back of the book has color images of the planets that can be used as coloring guides.

The Big Dipper and You

Edwin C. Krupp and Robin Rector Krupp (Illustrator), 48 pages, Mulberry Books, New York, 1999; ISBN 0-688-0719-0; paperback, $4.95.

Elaborate black-and-white pencil illustrations make this slim book a visual knockout. They also allow children to use colored pencils to add their own hues to the book. *The Big Dipper and You* is an introduction to skywatching. The asterism of the Big Dipper is easy to find and always visible from the Northern Hemisphere, making the book a perfect guide for the novice. The book also examines the forms that other cultures see in this star grouping and explains how to find the pole star using the dipper stars.

The Ultimate Moon Landing Sticker Book

Aled Herbert, 12 pages, DK Publishing, New York, 1999; ISBN 0-7894-4876-9; paperback, $6.95.

Sixty-three stickers of items relating to the moon landings, including a space meal, a lunar rover, and astronaut underwear, will keep your youngster entertained as he or she tries to match up the sticker with the correct silhouette and caption on the surrounding pages. The book has more stickers than silhouettes, which leaves leftovers for sticking on backpacks or lunch boxes.

The Best Book of the Moon

Ian Graham, 45 pages, Kingfisher, New York, 1999; ISBN 0-7534-5174-3; hardcover, $12.95.

The moon is one of the easiest astronomical objects for kids to learn. It's easy to find when it's up at night, and it's the brightest object in the evening sky. Even kids with early bedtimes can see it occasionally during the day. Attractive color illustrations depict the tides, eclipses, lunar features, and missions to the moon. A short glossary, an index, and a chart of eclipses throughout 2001 round out the book.

READING LEVEL: AGES 9-12

The Mystery of Mars

Sally Ride and Tam O'Shaughnessy, 48 pages, Crown Publishing, New York, 1999; ISBN 0-517-70927-4; hardcover, $17.95.

The book's highlight is the large assortment of unique, close-up images of Mars from the Viking, Pathfinder, and Mars Global Surveyor missions. The authors compare the formation of Earth with Mars and show how conditions on Earth favored the formation of life. Some recent spacecraft sent to explore Mars (the Climate Orbiter and the Polar Lander) were unfortunately lost, so some of the book's material is no longer valid. An overriding theme is the possibility of human missions to Mars; understandable in light of the fact that one of the authors is Sally Ride, the first American female astronaut. Another aspect that will appeal to young girls is the scenario involving a future Mars voyager. The astronaut/voyager in the book is referred to as "she."

Black Holes

Heather Couper and Nigel Henbest, 45 pages, DK Publishing, New York, 1996; ISBN 0-7894-0451-6; hardcover, $16.95.

Black Holes attempts to unravel the enigma of what these objects are and how they form. A discussion of gravity is central to understanding these concepts. The basics of how black holes were discovered and how relativity governs them ground the text. The authors also describe fanciful notions, such as falling into a black hole and traveling through time via a wormhole, that allow the imagination to soar. A center 4-page gatefold details the anatomy of a black hole.

Big Bang: The Story of the Universe

Heather Couper and Nigel Henbest, 45 pages, DK Publishing, New York, 1997; ISBN 0-7894-1484-8; hardcover, $16.95.

If your child liked *Black Holes*, *Big Bang* will also please her. Following the same format, a center gatefold contains a timeline from the Big Bang to the far future and recounts what elements were dominant for the given epochs. Each time period described in the gatefold is given its own spread with creative illustrations that clarify difficult, unobservable phenomena. If you know someone fascinated by how the tiniest particles evolved and combined to form the biggest known structures, then *Big Bang* will be right up her alley.

Is Anybody Out There?

Heather Couper and Nigel Henbest, 45 pages, DK Publishing, New York, 1998; ISBN 0-7894-2798-2; hardcover, $16.95.

Often an inflammatory subject, the topic of life beyond Earth forms the focus of *Is Anybody Out There?* The authors approach the subject seriously, detailing how life originated, possible habitats for life, the search for aliens, and the questions of how to define life and intelligence. Some well-known researchers, such as Jill Tarter, Frank Drake, and Freeman Dyson, have small sidebars dedicated to an explanation of their work.

Eyewitness Science: Astronomy

Kristen Lippincott, 64 pages, DK Publishing, New York, 1999; ISBN 0-7894-4888-2; hardcover, $15.95.

This book is just right for a young mind that enjoys both astronomy and history. The origins of astronomy, ancient astronomy and its uses, mythology, astrology, geocentricity, and other historical aspects of astronomy are explained with light text and lavish illustrations. The development of modern-day astronomy with sophisticated telescopes, space travel, and an exponentially increasing knowledge of the universe bring us up to the present.

The Young Astronomer

Harry Ford, 37 pages, DK Publishing, New York, 1998; ISBN 0-7894-2061-9; hardcover, $15.95.

This book is for children who can't sit still. Every page includes a different activity or experiment to try. Kids learn about the solar system by making their own model; they discover the changing phases of the moon by keeping a moon diary; and they can even make their own telescope for observing projects. Scout leaders and teachers will find many ways to occupy their charges in these pages.

The Kingfisher Young People's Book of Space

Martin Redfern, 96 pages, Kingfisher Books, New York, 1998; ISBN 0-7534-5136-0; hardcover, $19.95.

This Kingfisher book imitates the line of DK books in its style. Every two pages readers find another topic using lavish illustrations, brief text, and explanatory captions. The overriding theme is the search for our place in the universe. Exploration of space and a journey through our solar system and out to the edge of the universe give readers a broad sweep of how we fit into it all. The last section poses complex, unanswerable questions that will leave readers pondering the big picture.

The Planet Hunters: The Search for Other Worlds

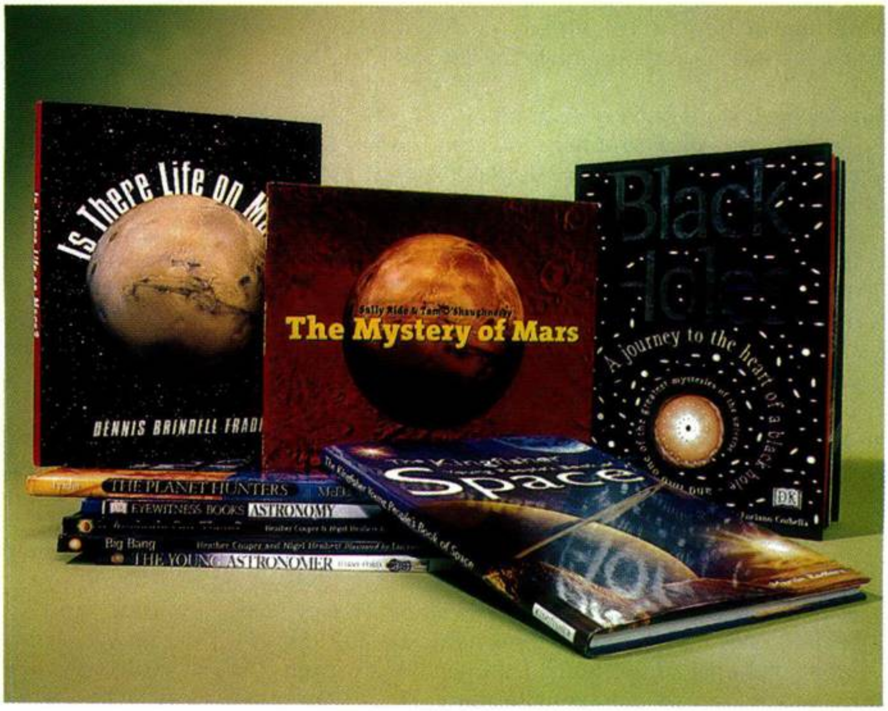
Dennis Brindell Fradin, 160 pages, Margaret K. McElderry Books, New York, 1997; ISBN 0-689-81323-6; hardcover, $19.95.

Unlike many other children's books on astronomy, the work of Dennis Fradin is short on images but long on words. You may even go a couple pages without seeing a picture — unimaginable in many books for children. Fradin's books seems much less like "kid's stuff" and will satisfy readers who feel they have outgrown such material. The chapters focus on the discovery and early knowledge of the planets and minor planets. The stories of Percival Lowell and Clyde Tombaugh and each man's search for Pluto is chronicled at length. The book wraps up with chapters on the discovery of planets outside our solar system and musings on extraterrestrial life.

Is There Life on Mars?

Dennis Brindell Fradin, 144 pages, Margaret K. McElderry Books, New York, 1999; ISBN 0-689-82048-8; hardcover, $19.95.

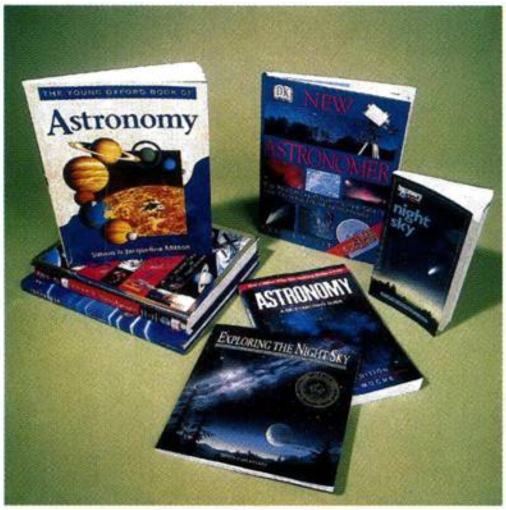
This work looks back at the history of the Red Planet and its future prospects for Earthlings. Some people in past centuries believed in martians, an idea furthered by Percival Lowell's claim of "canals" on the surface of Mars. But spacecraft that have studied the martian surface closely have found no indications of life. The prospect of future life on Mars gets a little space at the end of the book by exploring the possibilites of human colonization.



Exploring the Night Sky: The Equinox Astronomy Guide for Beginners

Terence Dickinson, 72 pages, Firefly Books, Buffalo, New York, 1997; ISBN 0-920656-66-8; paperback, $9.95.

Take a mental journey into space with this slim book. The first third of the work carries you outward from Earth, beginning just light-seconds away (the moon) to millions of light-years out. A familiar rundown of solar system objects, stars, and quasars follows. The last third of the work accelerates interest again by including illustrated sky maps with stargazing instructions. No labels or lines appear between the starry points, so it takes readers awhile to pick out familiar constellations and asterisms, just as it does when viewing the real night sky.



Night Sky: An Explore Your World Handbook

Robert Burnham (Editor), 192 pages, Discovery Books, New York, 1999; ISBN 1-56331-801-6; paperback, $13.95.

This compact, portable volume has four main divisions: one with scientific facts about the sun, planets, stars, and galaxies; another on recent explorations and science developments; one on how to skywatch; while the last provides maps and observing highlights in each of the constellations. The last section is destined to get the most use. A map of the full moon labels prominent craters and locations of manned moon landings. Maps for each season and hemisphere lead into a listing of the 88 constellations and the brightest deep-sky objects and stars of note found within their boundaries. Although there is a lot of good information packed within, watch out for occasional errors and mislabelings I found in the last half of the book.

The Young Oxford Book of Astronomy

Simon and Jacqueline Mitton, 160 pages, Oxford University Press, New York, 1998; ISBN 0-19-521445-5; paperback, $16.95.

If you are looking for an astronomy textbook for students at the junior or senior high level, *The Young Oxford Book of Astronomy* can fit the bill. One of the better features of this text is the occasional observing note tied to the science lesson. The section on "Lives of the Stars" includes a box that instructs readers on how to see a stellar birthplace (the Orion Nebula) and a star cluster (the Pleiades). Where other books on this subject focus on the solar system and give a broad and fanciful sweep over other topics, here the standard planet fare has to compete with a healthy dose of more difficult subjects such as parallax, quasars, and exotic stars.

The Universe Revealed

Pam Spence (Editor), 45 pages, Cambridge University Press, New York, 1998; ISBN 0-521-64239-6; hardcover, $39.95.

At a somewhat sophisticated level, the book explains the solar system and cosmology with more depth than other beginning astronomy books. In addition, sections on light pollution, global warming, and similar topics step away from the strict facts and figures of science to explore how society's daily life affects the planet as a whole. This work's primary drawback is the British spellings of words such as centre and colour.

New Astronomer

Carole Stott, 144 pages, DK Publishing, New York, 1999; ISBN 0-7894-4175-6; hardcover, $24.95.

This book's title may be misleading: Observing, not science, is the main subject, and a small cardboard planisphere is included. If you want to know when to observe Saturn and how naked-eye, binocular, telescopic, or CCD views of the planet differ, then you're in luck. Key constellations and their deep-sky objects are included in monthly listings. But if you're looking for anything beyond a beginner's level of observing, look somewhere else.

Space Encyclopedia

Heather Couper and Nigel Henbest, 304 pages, DK Publishing, New York, 1999; ISBN 0-7894-4708-8; hardcover, $29.95.

This work employs the familiar DK style and organizes the material by subject matter, not alphabetically. The volume could aid kids with their homework. If a student had a report due on asteroids, she could glean information from the two pages dedicated solely to asteroids and then move to the "Find out more" box in the corner, which will direct her to supplemental information. In this computerized age, however, the book may be entirely forgotten and the focus will probably fall on the PC compatible CD-ROM included with the book. The same text and images appear on both the book's pages and computer's screen, but the CD offers games to quiz students on what they have learned. Other electronic activities include building space rockets and landing spacecraft on Mars.

Astronomy: A Self-Teaching Guide, 4th Edition

Dinah L. Moché, 347 pages, John Wiley and Sons, New York, 1999; ISBN 0-471-53001-8; paperback, $18.95.

The pages may not be glossy and the pictures are black-and-white, but this compact book packs in the information. A home-schooler or student wishing to get a jump start on college astronomy work will find this volume valuable. Each chapter begins with a list of objectives that readers should learn; short questions await at the end of each section. A self-test lets students review the material they just learned. Questions include "Write the general formula that relates the wavelength and frequency of a wave," "Define the astronomical unit," and "List two basic observations that can help decide between an open and closed universe." The authors don't leave you guessing. If you have to check, answers are supplied.

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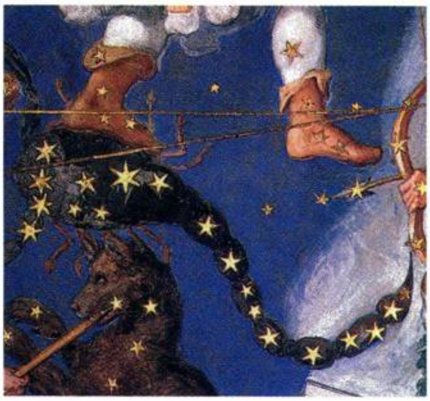


Filled with Milky Way treasures, the scorpion offers a cornucopia of open and globular clusters as well as bright nebulae.

by Tom Polakis

THE WARM, SHORT NIGHTS OF summer invite long looks toward the richest parts of our galaxy. Yet few of these regions can match Scorpius the Scorpion for the number and quality of deep-sky sights. The figure of Scorpius appears unmistakable in the south on summer evenings, looking surprisingly like its namesake.

First-magnitude Antares marks the heart of the scorpion. This red supergiant star lies 600 light-years from Earth and shines with the light of nearly 20,000 suns. The very name suggests its noticeably reddish color, coming from the Greek words *anti Ares*, which mean "rival of Mars." Two 3rd-magnitude stars flank Antares, Sigma (σ) Scorpii to the northwest and Tau (τ) Scorpii to the southeast. The most distinctive feature of Scorpius, however, is the arc of seven bright stars that forms the scorpion's stinger. Although the stinger lies fairly far south for Northern Hemisphere observers, it clears the horizon from most of the United States.

Your best introduction to Scorpius will come at a dark site using nothing more than your naked eye or a pair of binoculars. The plane of the Milky Way Galaxy passes through the stinger of the scorpion, where you'll find plenty of bright star clouds and dark dust lanes. To the stinger's north lies a large, circular star cloud about 5° across. Even small binoculars will resolve this glow into countless stars. Farther north, the Milky Way's presence diminishes but does not vanish. Several dark lanes that enter Scorpius from its northern neighbor, Ophiuchus, can be seen in large binoculars, with the southernmost appearing most prominent. At the darkest sites, you can trace the Milky Way's central bulge as far west as Delta (δ) Scorpii, more than 20° from the galaxy's equator.

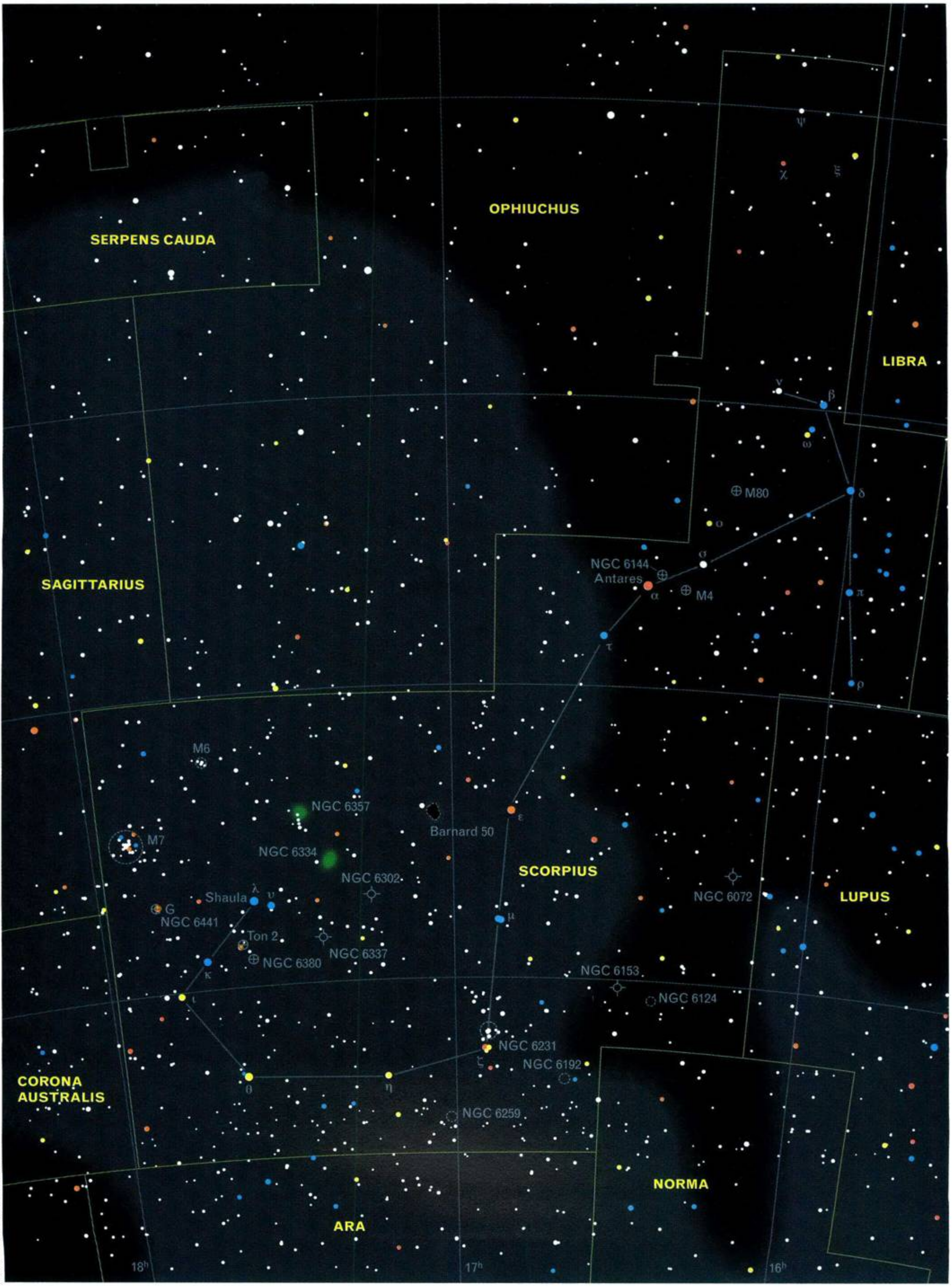
Our telescopic tour begins at the heart of the scorpion. **Antares** resolves into a pleasing double star when Earth's atmosphere is stable. The companion was unknown before 1819, when astronomers detected it during a lunar occultation. It currently lies 2.6" west of Antares. The large magnitude difference between the two stars makes this double harder to split than the separation would indicate. Use as much magnification as the seeing conditions allow and you might glimpse the 5.4-magnitude secondary nearly touching Antares. The best views often occur during twilight, when the seeing steadies and bright stars don't appear so overwhelming in the eyepiece.

Look a little more than 1° west of Antares and you'll find a spectacular globular cluster. Not only does **M4** (NGC 6121) lie closer to a 1st-magnitude star than any other Messier object, it also ranks as the closest globular cluster to Earth. At a distance of only 5,600 light-years, you might think it would appear brighter, but intervening dust dims its light by a full magnitude. Keen-eyed observers should have no problem spotting M4 without optical aid. In a 6-inch telescope, dozens of stars scatter loosely across 8' and a prominent chain of stars runs north-south through the cluster's center. A 13-inch scope at 200x brings out a couple hundred stars between 11th and 15th magnitude. A flood of fainter star patterns now diminishes the north-south chain. Astronomers classify M4 as a loose

Artwork at left from *The Glorious Constellations*, © 1991; Harry N. Abrams, Inc.

NGC 6357 (top) and NGC 6334

George Greaney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Astronomy: Elisabeth Rowan

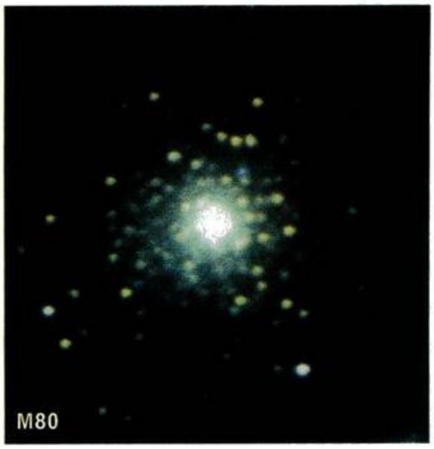
globular cluster, and in a large scope it shows only the slightest glow of unresolved stars across the central 3'.

Pan about one-third of the way from Antares to M4 and head a little bit north to locate another fine globular cluster. **NGC 6144** contrasts nicely with M4, which you can see in the same field at low magnification. To resolve it, you'll need to see stars down to 13th magnitude. An 8-inch scope at high magnification fits the bill, revealing a dozen stars mainly around the edge of a well-concentrated haze 4' across. NGC 6144 follows a tight orbit around the Milky Way's center that currently places it some 30,000 light-years from Earth. It also lies on the southern edge of a large dark nebula that obscures most stars from view. Before departing the region, slowly sweep to the north with a low-power eyepiece and notice the eerie, starless fields.

Head just 4° to the northwest and you'll arrive at another of Messier's globular clusters, **M80** (NGC 6093). It lies 12,000 light-years from the center of the galaxy and nearly three times that far from Earth. One of the densest globulars in the Milky Way, M80 proves difficult to resolve in smaller instruments. An 8-inch scope shows a bright, highly concentrated center with a handful of stars strewn about the edge. Roughly 50 stars can be resolved in a 13-inch scope, while the count doubles in a 20 inch.

Despite the attractions in northern Scorpius, the real action lies farther south. First up is **NGC 6072**, a bright planetary nebula 8° west-southwest of the 2nd-magnitude star Epsilon (ε) Scorpii. Easy to glimpse in a 6-inch telescope, it appears as a uniform, circular disk about 1' across. With a nebula filter and a large scope, a slightly darker rift seems to split NGC 6072 into northern and southern lobes. The planetary formed when a star with perhaps a few times the mass of the sun reached the end of its life and puffed off its outer layers.

The rich open star cluster **NGC 6124** lies 5° south-southeast of the planetary. Barely visible to the naked eye under excellent conditions, a small finderscope easily brings it into view. A small refractor reveals a couple dozen stars brighter than 10th magnitude. In a scope of moderate aperture, 60 stars scatter across a half-degree field. The stars stand out nicely against the sparse background field.



Ben Mayer

A bit more than 1° east-northeast lies another of the many planetary nebulae in Scorpius. **NGC 6153** appears as a bright, circular disk about 20" across. Crank the power to at least 200x to look for structure. My 13-inch telescope reveals a hazy edge and hints of a dark center. As with any planetary nebula, a narrow-band nebula filter helps bring detail into view.

Deep-Sky Objects in Scorpius

Object	R. A. (2000.0)	Dec.	Mag.	Size/Sep.	Type	Notes
NGC 6072	16h13.0m	–36°14'	11.7	40"	PN	
M80 (NGC 6093)	16h17.0m	–22°59'	7.3	8.9'	GC	
M4 (NGC 6121)	16h23.6m	–26°32'	5.8	26.3'	GC	
NGC 6124	16h25.6m	–40°40'	5.8	29'	OC	
NGC 6144	16h27.3m	–26°02'	9.0	9.3'	GC	
Alpha Scorpii	16h29.4m	–26°26'	1.1/5.4	2.6"	Dbl	Antares
NGC 6153	16h31.5m	–40°15'	10.9	25"	PN	
NGC 6192	16h40.3m	–43°22'	8.5	7'	OC	
NGC 6231	16h54.0m	–41°48'	2.6	14'	OC	
NGC 6259	17h00.7m	–44°40'	8.0	8'	OC	
Barnard 50	17h02.9m	–34°24'	—	15'	DN	
NGC 6302	17h13.7m	–37°06'	9.6	2' by 1'	PN	Bug Nebula
NGC 6334	17h20.4m	–35°51'	—	35' by 20'	BN	Cat's Paw Nebula
NGC 6337	17h22.3m	–38°29'	12.3	48"	PN	
NGC 6357	17h24.7m	–34°12'	—	25'	BN	
NGC 6380	17h34.5m	–39°04'	11.1	3.9'	GC	
Ton 2	17h36.2m	–38°33'	12.2	3.4'	GC	
M6 (NGC 6405)	17h40.1m	–32°13'	4.2	33'	OC	Butterfly Cluster
NGC 6441	17h50.2m	–37°03'	7.2	7.8'	GC	
M7 (NGC 6475)	17h53.9m	–34°49'	3.3	80'	OC	Ptolemy's Cluster

Object: Designation in Messier, NGC, or other catalog. **R.A. (2000.0) and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size/Sep.:** Size in arcminutes or arcseconds; separation in arcseconds.

The Scorpion

"While Fell was reposing himself in the hay,
A reptile concealed bit his leg as he lay;
But, venom himself, of the wound he made light,
And got well, while the scorpion died of the bite."
Paraphrase of a Greek Epigram by Demodocus
Gotthold Ephraim Lessing (1729–1781)

With a graceful arc of stars that looks like a coiled tail, it's no wonder that most ancient skywatchers saw a scorpion in the pattern of Scorpius. Greek myth is rife with accounts of the arachnid's activities, with even the mighty hunter Orion succumbing to the deadly animal. In one version of the story, the scorpion ambushed Orion as he walked along a favorite hunting trail.

In another version, Orion escaped from Scorpius by diving into the sea. He swam toward the island of Delos, home of Artemis, the goddess of the hunt and his lover. Artemis's twin brother, Apollo, saw what was happening and challenged Artemis to show her skill with bow and arrow by hitting the distant, indistinct target. She did, of course, and became disconsolate when the body washed ashore. Zeus elevated both Scorpius and Orion to the heavens but placed them far apart, so Orion would dip below the horizon just as Scorpius rose into view.

Scorpius also led to the downfall of Phaethon, Apollo's bold yet inexperienced son, who one day attempted to drive the chariot of the sun across the sky. Phaethon panicked at the sight of the scorpion and lost control of his steeds. The sun scorched Earth, creating the Sahara Desert, and Phaethon plunged to his death in the river Eridanus.

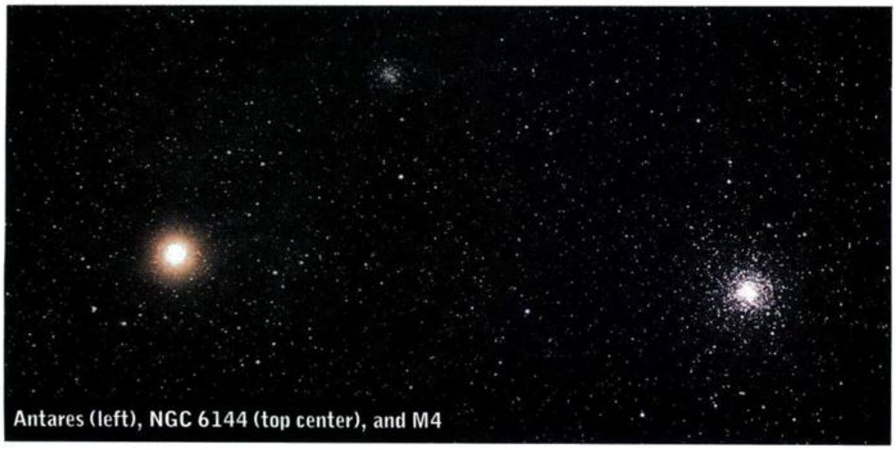
To natives of the South Pacific, this star pattern has more to do with birth than death. They saw the arc of stars as a magic fishhook belonging to a young fisherman named Maui. He cast the hook into the sea and landed a real whopper. As he reeled in his catch, he found to his amazement that he had snagged an entire island, complete with plants, animals, and even humans. In his joy, he threw the fishhook into the sky, creating our constellation Scorpius. The island became known as "the fish of Maui" — our New Zealand. — *Richard Talcott*

Probing still farther south, we come to the open cluster **NGC 6192**. A 10-inch telescope shows 40 stars that span 7' and appear well detached from the surrounding Milky Way. Most of the members glow between 11th and 14th magnitude.

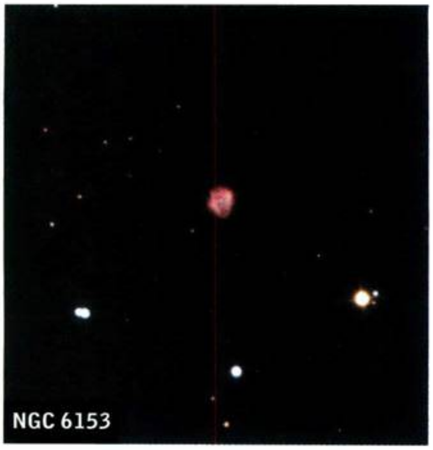
An immense group of hot, young stars known as the Scorpius OB1 association extends more than halfway from Zeta (ζ) to Mu (μ) Scorpii. To the naked eye, this thin band of stars looks like a large, diffuse comet. Binoculars break the association into several dozen bright stars set against a clumpy background. Look toward the association's southern end to find the magnificent open cluster **NGC 6231**. Although visible as a hazy patch without optical aid — no mean feat at its distance of about 6,000 light-years — to fully appreciate the cluster you need to view it through a telescope. Fortunately, just about any telescope will do.

NGC 6231 offers more than 100 stars in a spectacular grouping that spans 12'. Particularly striking is the knot of half a dozen bright stars at the cluster's center. Most of the surrounding stars glow at 10th or 11th magnitude and fall well within range of a 4-inch telescope. The cluster stands out nicely from the surrounding star field, especially on the sharply defined eastern and southwestern edges. While you're at the eyepiece, sweep north through the dazzling starscape. Hundreds of moderately bright stars arranged in clumps pack several 1° fields. At the northern end of the Scorpius OB1 association lies NGC 6242, a fine cluster of 50 stars in its own right.

Down where Scorpius borders its southern neighbor Ara, you'll come across **NGC 6259**. The subtle beauty of this open cluster contrasts starkly with the sparkle of NGC 6231. A 10-inch scope shows nearly a hundred stars fainter than 12th magnitude in a well-


Luke Dodd

Antares (left), NGC 6144 (top center), and M4


Jack Marling

NGC 6153

NGC 6231

Gianni Tumino and Melania Pluchinotta

NGC 6302

Ken and Matt Blankenship

M6 (left) and M7

Tim Barnwell

defined area 7' across. A tiny, detached group of 15 similarly bright stars lies 10' west.

The attractive planetary nebula **NGC 6337** rests inside the arc of stars that forms the scorpion's stinger. A 13-inch telescope at 200x shows a thin ring 40" across with a superposed star on both the north and south faces. In smaller scopes, a nebula filter really helps to reveal the annular form.

Just 2° northwest of NGC 6337 lies one of the brightest and most massive planetary nebulae known. The **Bug Nebula** (NGC 6302) packs an enormous amount of detail into an object some 5,000 light-years away. In a medium-sized Newtonian, it at first appears like a bright galaxy 80" long and 20" wide. A prominent lobe with a tapered end makes up the western side of the nebula. A faint "arm" radiates from the blunt-ended eastern segment, which appears separated from the rest. The planetary's central star must be extraordinarily hot — perhaps as much as 350,000 kelvins (630,000° F) — and thus very bright, but has never been seen. Intervening dust dims it by as much as five magnitudes.

Two degrees northeast of the Bug dwells another of the many objects in Scorpius deserving of superlatives. The **Cat's Paw Nebula** (NGC 6334) rates among the largest star-forming regions in the Milky Way. Best viewed with a nebula filter, it presents five individual nebulous patches in a circular area half a degree across. The brightest lies on the southeastern end of the complex. It measures 6' across and contains a 9th-magnitude star. To its west is a slightly dimmer nebula of similar size with a bright, small object to its north. Rounding out the view are two fainter patches at the northern edge of a medium-power telescopic field.

A similarly impressive region of star formation can be found 2° to the north-northeast. The emission nebula **NGC 6357** surrounds the open cluster Pismis 24, whose stars excite the nebula's gas to glow. Catalogs claim NGC 6357 spans nearly 0.5°, but only the bright region west of center can be seen in small telescopes. A narrowband nebula filter shows a bright, uniform glow measuring 2' by 1'.

Of the many dark nebulae along the galactic plane in Scorpius, **Barnard 50** stands out. This dusty region looks most defined on the eastern edge, where it meets a star cloud and a chain of three stars. The nebula appears 15' across and irregularly shaped.

Two heavily obscured globular clusters also lie along the galaxy's plane. Viewed through 35,000 light-years of intervening material, **NGC 6380** presents a challenge to a 12-inch telescope under dark skies. Its brightest stars glow at 17th magnitude, so you can only hope to catch a faint haze. Using a 20-inch scope at a superb site in southern Arizona, I managed to see a broadly concentrated halo 1' across.

If NGC 6380 fails to test your abilities sufficiently, aim 0.6° northeast to bring in still fainter **Tonantzintla 2.** Although just three-quarters as far away as NGC 6380, Ton 2 presents a far greater observational challenge. The 20-inch scope showed only an extremely faint, uniform haze some 2' across amidst a very rich star field. More than a dozen other globular clusters call Scorpius home, some even more obscure than these two.

A much brighter globular cluster lies 3° east-northeast of Ton 2. You can spy **NGC 6441** in a finderscope, right next to the 3rd-magnitude star G Scorpii. Although the presence of this orangish star just 4' from the cluster's center adds an aesthetic touch, its glare certainly impedes resolution. NGC 6441 is one of only four globular clusters known to contain a planetary nebula, but you'll need a 25-inch or larger telescope to spot it.

One of the more celebrated open clusters resides northeast of the stinger's tip. First mentioned by the 2nd-century astronomer Ptolemy, **M7** (NGC 6475) lies 900 light-years away and ranks among the dozen nearest open clusters. It contains 12 widely scattered members of 7th magnitude or brighter, which makes it one of the few clusters that can be resolved with the naked eye. A pair of 10x50 binoculars shows 50 stars spread across a diameter of 1°, while a 4-inch telescope doubles that count. The stars are arranged in clumps that create starless lanes crossing the cluster.

Pan just 4° northwest of M7 and you'll find another naked-eye open cluster, **M6** (NGC 6405). Also called the Butterfly Cluster, M6 lies twice as far away as its companion and thus shows its brightest stars with more difficulty. Even the slightest optical aid will bring 10 stars into view in an area 15' across. In a 6-inch telescope at 50x, M6 shows 60 stars mostly between 8th and 11th magnitude. As with M7, the cluster looks best at low power, and larger telescopes do little to improve the view. Before heading inside, take a few minutes to scan the star fields in the vicinity of M6 and M7. They are among the richest in the heavens and great territory for sweeping with a rich-field telescope. ■

Tom Polakis is an aerospace engineer who lives in Tempe, Arizona. His favorite astronomical pursuits are deep-sky observing and photography.

ReEnergize Your Astro Club

Ten tips for pulling your star club out of its black hole.

By Penny Fischer

Every month, it's the same story. You're looking forward to your next astronomy club meeting with high hopes. Perhaps something exciting will happen this month: A great star party? An interesting speaker? A new club project? Or maybe your club will finally decide to participate in some public education sessions. That hope quickly evaporates as you sit down and the meeting commences. A feeling of déjà vu overtakes you.

Your astronomy club is overladen with politics and parliamentary procedures. Formal motions dictate everything, including where to purchase coffee and doughnuts. The same few members raise the same complaints all over again. In all the interminable discussion, no one offers any constructive solutions to the problems plaguing your club. Before long, it's 10 P.M., and the meeting wraps up. Once again, the club spent no time discussing astronomy.

On the drive home, the realization hits: Instead of being fun, your star club is a drag. You long for the days when members couldn't wait for the meetings and eagerly anticipated those nighttime observing sessions. If only you could reignite that spark, reenergize the club, make it as much fun as when you first discovered astronomy. But how?

We found a way.

Our astronomy club, S*T*A*R (the Society for Telescopy, Astronomy and Radio, or STAR), in New Jersey, found itself in this very situation a few years ago. STAR stagnated to the point of almost going defunct. Membership fell to a pitiful number. That's when club president Dan Pontone, vice president Don Odegard, and I put our heads together and decided to take action — fast.

We made a conscious effort to make the changes, but we went with the flow, capitalizing on situations as they arose. Mostly, we became doers. We pushed other members to become doers, too. Here are some tips that worked for us:

❶ Exploit Astronomical Events

Think exposure, exposure, exposure. Use meteor showers, eclipses, comets, and other astronomical events to pique the public's interest and awareness. Serendipity sometimes plays a hand. For instance, STAR hitched a ride on the coattails of Hale-Bopp. We capitalized on the comet by publicizing our club any way we could. Local papers welcomed comments about Hale-Bopp from STAR club members. We hosted star parties whenever and wherever possible. Because this comet was visible from suburbia, we held a star party in the parking lot of a local bookstore.

Although we gained some new members because of the Hale-Bopp craze, we also realized many of them would lose interest soon after the comet reached perihelion. Still, we were confident that some of the new members — their interest in astronomy awakened — would remain with us.

❷ Cater to New Members

New members often suffer stage fright when they walk into a meeting room filled with people who have known each other for years. Let newcomers know that it's normal for budding astronomers to find our scientific jargon intimidating. STAR found that taking newcomers under our wings benefited everyone. Dan Pontone does a wonderful job helping to welcome new members. He takes them out to our dark-sky site himself and treats them to a private showing of the constellations and some easy planetary and deep-sky objects. You could also appoint members to mentor newcomers.

❸ Delegate and Do It

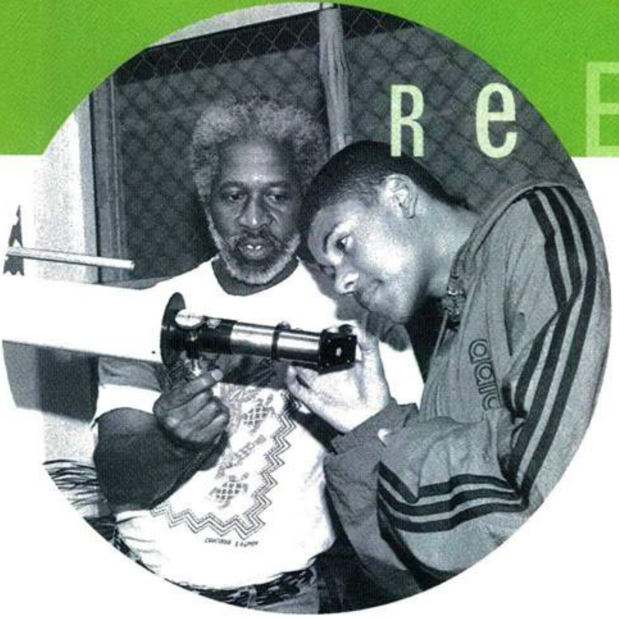
Does your club have a newsletter? A web page? Do you produce T-shirts, sweatshirts, and hats with the club's logo on them? Do you have a few social gatherings yearly, such as club Christmas parties or summer picnics? Get all your members (especially new ones) involved in these events. It helps everyone get more comfortable with each other. And, we found that the more people we involved in different projects, the more we accomplished.

If the size of your club warrants, divide duties and responsibilities broadly, allowing different members to act as newsletter editor, program coordinator, webmaster, club activities coordinator, and so on. Every one of your members has a skill — discover what it is and use it. Assign tasks for short terms so that no one feels overwhelmed with responsibility. We made sure to offer those who complained the loudest the opportunity to take charge of some aspect of our club.

Astronomy clubs can help spark an interest in astronomy early on to encourage a lifelong passion. Astronomical Society of the Pacific

STAR FINDER

reExperience



Technical skills learned during the formative years remain valuable throughout one's lifetime. Astronomical Society of the Pacific

4 Think Internet

Our club posts pictures, articles, and activities on its web page (www.starastronomy.org). We also set up a bulletin board, and it has been the single major reason for our rebirth. We set up four categories that made this club truly interactive: Club Activities, Astro Equipment, Observing Reports, and General Astronomy. Bulletin boards are commercially available on the web and worth every penny. We hold many animated discussions on the board about our astro-toys. More importantly, the board helps new members get great, accurate information on equipment — something most astronomy neophytes seek. In addition, by using our Internet bulletin board, we coordinate impromptu observing sessions easily and quickly.

Which leads me to . . .

Children possess a natural tendency to share their sense of wonder about astronomy with others. Astronomical Society of the Pacific

5 Get Out and Observe!

STAR abides in New Jersey — not exactly famous for pristine, transparent skies. Nevertheless, our club found a decent dark-sky site in a local wildlife management area. And we use it. Remember that most people join astronomy clubs to get help or company while stargazing, not to sit and listen to people drone on and on about optical aberrations.

Make observing an integral part of your club — in fact, make it the focus. Plan observing sessions every month on a weekend night closest to the new moon. In between times, schedule special observing sessions according to time constraints and astronomical events.

6 Teach and Inspire

Here's your chance to inspire the next generation. Our club volunteers to teach astronomy at a local school. Aim for fourth-through-sixth graders. Kids aged 10 to 12 are the most enthusiastic audience you will ever find. Several members of STAR teach their specialty — satellite viewing, telescope making, and how to discover and use astronomy resources from the Internet — on a regular basis. Teaching is not only fun for

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us, but it may also spark a lifelong interest in someone young and impressionable.

We sponsor a lot of public star parties. They are easy and fun. Set up your equipment to view nothing more complicated than a few bright planets, the quarter moon, and perhaps a pretty double star, such as Albireo. Our club slants its star parties toward the education of youngsters: boy scouts, girl scouts (and their parents, who often get more excited than the kids). Can't find a venue? Check with your local parks, which usually welcome groups wishing to host programs, activities, or observing sessions.

7 Encourage Club Projects

STAR is about to build two new club telescopes, and we plan to involve quite a few members in the construction project. We also completed several special-interest projects last year, including building a Dob-driver – a simple electrical device and platform that allows a Dobsonian scope to track the stars.

Camaraderie among club members always increases when people get involved in learning, planning, and/or building. Give your members the opportunity to participate and they will.

Influence the Next Generation:

Get kids interested in astronomy early.

Star clubs can almost guarantee their own survival by sparking a curiosity in astronomy at a young age.

Volunteer at local schools for special activity days.

Introduce kids to binoculars and telescopes in a friendly environment.

8 Invite Speakers

STAR's members live within driving distance of Rutgers and Princeton Universities, from where we recruit knowledgeable speakers on all kinds of topics. Surely your club has a university or college nearby. Contact its science and astronomy departments, but don't overlook other, nonastronomical sciences.

For example, one time a local professor of geology presented a wonderful guest lecture on the Antarctic Meteorite Program (in which he participated). He also shared his thoughts and ideas about ALH84001, the famous martian meteorite.

Finally, don't forget to mine the talents and knowledge of your own members. Find out if one of your members does astrophotography. Perhaps she's willing to do a slide-show presentation. Get your best storyteller to describe the lighter side as well as the frustrations of stargazing. Or, maybe the master scope builder in your club would love to speak about his favorite project: Ask him.

Set up your scopes outside on the playground if weather permits.

Otherwise, plan a short program for an inside assembly that encourages children to look to the stars for a lifelong hobby.

9 Display Your Equipment

We started a new short segment each month at our meetings. One member brings in his or her scope and talks about it for five or ten minutes, describing its features, construction, and capabilities. This acquaints newcomers with a different type of scope each month, so they can learn the advantages and disadvantages of the various types — what they look like, how large and heavy they are to transport, how easy to set up. It also allows for a hands-on experience that gives newcomers more opportunity to familiarize themselves with telescopes. Unlike the nighttime outdoor observing sessions, members see equipment under bright lights instead of in the dark.

10 Interact With Other Local Clubs

STAR considers other local clubs an asset rather than competition. In fact, quite a few of our members belong to more than one astronomy club. We welcome anyone with an interest in astronomy, regardless of his or her prior or current affiliation.

STAR also works in conjunction with its sister clubs to coordinate public awareness events, including star parties. Additionally, we find in our local sister clubs a great resource for guest speakers.

Using these techniques, STAR effectively doubled its membership in a year's time. And, membership continues to grow at (forgive me) an astronomical rate.

I hope your club does the same. With a little bit of effort and enough motivation to want to make your club more exciting, you too will achieve positive results faster than expected.

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*Penny Fischer is the current president of S*T*A*R. She's also a former Special Contributor for Space Exploration for Prodigy Internet Services. Penny shares her lifelong enthusiasm for astronomy with her daughters — both avid stargazers. For a pleasant mixture of astronomical delights, visit Penny's website at www.monmouth.com/~govega.*

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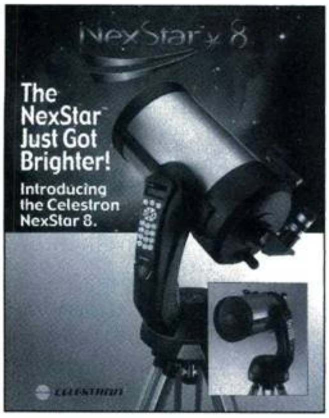
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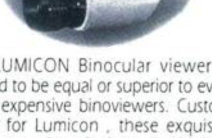

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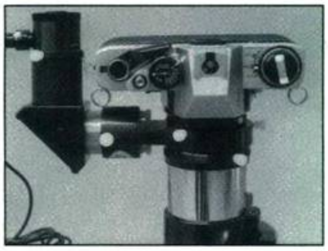

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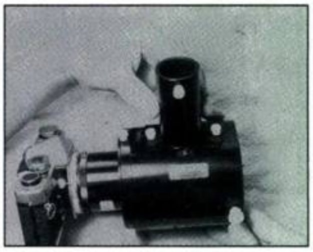

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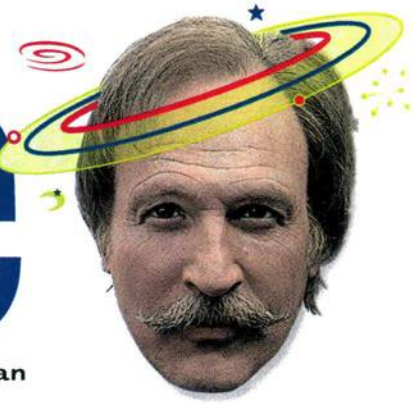

By Bob Berman

2001 Space Oddities

Some people are surprised that the moon's rotation and revolution counter each other, so that it always keeps one face toward Earth. But most of us know that this is no coincidence. Many of Jupiter's moons show the same synchronized spin. This effect is eventually produced wherever a body's tidal effect influences a lighter nearby neighbor.

Still, the universe is full of wonderful oddities. They make for good conversation with science-minded companions and can serve as a worthy "soundtrack" whenever you're pointing out the constellations.

Here are some of my favorites, gathered from many years of reading and personal observation. I present them with no philosophic agenda in mind. I am not trying to prove that the universe is peculiar (though it is certainly that) or that some Grand Plan is afoot. What I present here is intended to provide some "hey, wow!" material for your next sky session. I've mentioned about half of these in my books, but I'll bet that few readers, if any, know every one of these nuggets. Try 'em out, and see how many are new to you.

The nearest spiral galaxy, Andromeda, displays the same nearly edgewise (13°) slant to us that we do to it. That the Andromeda Galaxy lies so near the Milky Way in the autumn sky is proof that we must be nearly edge-on to any Andromedans looking our way.

The moon and sun appear the same size in our sky (thus, total solar eclipses). But none of the solar system's 65 other moons look that way to their parent planets.

For centuries, Mercury's day (rotation period) was believed to match its year of 88 Earth days. The discovery of its 59-day rotation totally destroyed that matchup. Or did it? Amazingly, the antiquated textbooks remain true in a way, because the combination of its revolution and rotation makes Mercury's "day" (meaning its period of uninterrupted sunshine) — 88 days long!

The moon is the only known body that moves through space at its own diameter each hour. That's why it takes approximately an hour for both solar and lunar eclipses to progress from start to totality.

The number of inches in a mile is essentially the same as the number of astronomical units (Earth-sun distances) in a light-year. (The former divided by the latter equals 1.002.)

Jupiter's three innermost large moons orbit in a precise 1–2–4 ratio. That is, Io makes four orbits as Europa makes two and Ganymede makes one.

Light travels a foot of distance in a nanosecond (billionth of a second). Okay, 11 and ¾ inches.

The sun's diameter in miles is very nearly one "power of ten" greater than the number of seconds in a day.

For ⅞ of the time life existed on Earth, it was microscopic and utterly invisible to the eye. If extraterrestrial life follows our pattern, a random life-bearing planet might reveal no trace of life to a visitor, even as it lay all around her.

The most shocking astronomical discovery of all time probably was Uranus in 1781. Absolutely nobody had imagined that there might be additional planets beyond the five known since prehistory.

Earth is the only known body with a consistently blue sky. Mars comes closest, its sky varying from salmon pink to blue, depending on the amount of airborne dust at the time.

The moon is the only major satellite that does not revolve around its parent planet's equator. Instead of following our celestial equator and journeying through Orion's belt each month, it ignores our planet's tilt and instead orbits in the same plane as the planets.

Galileo's drawings show that he observed Uranus 170 years before its official discovery.

The sun is not yellow-white. It is pure white. Air preferentially scatters the sun's shorter wavelengths (giving us our blue sky), which leaves sunlight with less blue and hence a lemony hue. The color of snow closely matches the sun's actual color (because snow reflects the sky's blueness as well as sunlight; this recombination restores our nearest star's true tint).

The same counterclockwise motion made by stars as they slowly revolve around Polaris is also displayed by the revolution of all planets, the sun, and all the major moons with one exception: Only Neptune's Triton goes the "wrong way."

Venus's day is longer than its year (243 days versus 225). But the cloud-covered world really barely moves at all. Its leisurely spin, the slowest of any known body in the universe, would allow a venusian equatorial inhabitant to keep nightfall at bay just by walking in the right direction.

The weight of the universe in tons is roughly a one followed by 50 zeroes.

The current resolution of Earth's best telescopes translates into about two city blocks on the moon. Therefore, no trace can be seen of spacecraft or debris left behind by the Apollo program. Yet the newly approved FAME astrometric telescope would be able to resolve a fly on the Leaning Tower of Pisa as seen from New York.

The name "Richard Nixon" appears on six plaques left on the lunar surface. Those words may be legible for a half bil-

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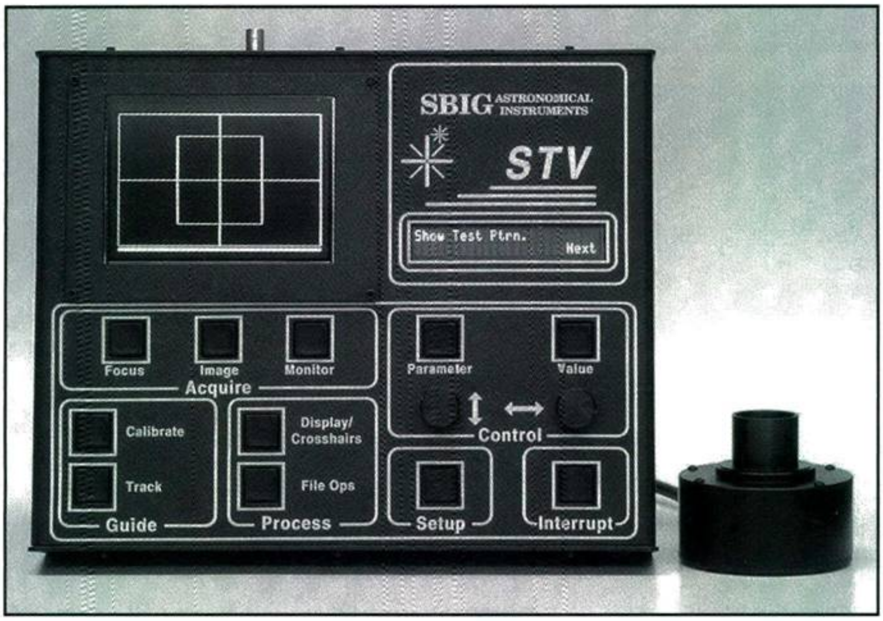
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lion years, a hundred thousand times longer than the pyramids have existed to date. That name will easily outlast the human race.

Every second the sun weighs four million tons less than it did before. This is how much mass is continually lost in its conversion to energy.

If the sun suddenly blew up, the crescent moon would wink out almost simultaneously, but the dim glow of Earthshine would bathe the moon's disk for an additional three seconds. (If you ever see this happen, grab a phone and sell your stocks. You'll have a three-second head start .)

In 1927, the Belgian astronomer George Lemaître was the first to declare that the universe started as a small, hot, superdense ball. He called it a "cosmic egg." Big Bang was not the name of that idea, only a term derisively used decades later to dismiss it.

Earth's 1,500-mile diameter core spins at a different speed than the rest of the planet.

Murphy's law actually originated with a man named Murphy. In 1949 Captain Aloysius Murphy was testing an experimental rocket sled whose sensors had been installed backward.

If Betelgeuse were represented as a ball with a diameter equal to a 20-story building, a relative Earth would be the period at the end of this sentence.

Some of the above has been simplified for brevity, which I mention in the hope of avoiding gotcha letters and mad theories — like the hypothesis that Andromeda looks to us as we do to Andromedans because there's a giant mirror out there and we are actually seeing ourselves. Come to think of it, that's no worse than Hawking's belief in backwards time. There's no dearth of oddities, factual or improbable, in this vast cosmic playground.

Bob Berman's Strange Universe column is only one of the many tasks he performs for Astronomy *magazine. His guide to dark places will appear in the next issue. And he also is author of* Secrets of the Night Sky.

Bob asks your help. If you know of oddities or coincidences he neglected in this column, please contact him at Skymanbob@aol.com.

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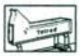

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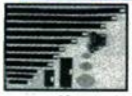

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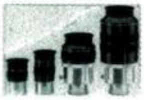

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PANOPTICS 68° Apparent Field of View
15MM $210., 19MM $240., 22MM $280., 27MM (2") $330., 35MM (2") $365.

MONTHLY SPECIAL

PRONTO w/2" DIAGONALPanoramic Mount and Quick Point Finder
POCONO MOUNTAIN OPTICS EXCLUSIVE

2.5x Powermate	$168.00
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New 4x Powermate now avail.	$265.
New Bino Vue	$1030.00
8MM to 24MM ZOOM	$210.00
New Everbrite 2" Star Diag.	$255.00

Ranger, Pronto, TV-85 in stock

CELESTRON

We carry the full line of Celestron Telescopes and Accessories

NEW NEXSTAR 5 & 8

JUST ARRIVED!
Flawless go-to and tracking. Superb optics, very quiet. A real winner!
Nexstar 5 $1199.
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CELESTAR 8 DELUXE

2032 MM FL., Heavy Duty Adj. Tripod Dec Motor and Hand Control. 4 Tracking Rates and PEC Fastar Compatable. In Stock for Immediate Shipment. $1699.
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Mention Ad A-7

Anyone can sell you a telescope.

Authorized Meade Dealer

Meade ETX-90EC
$595
Meade ETX-125EC
$895
#497 Autostar
$149

Hardly a day goes by that we don't get a note or E-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. So and so on the East Coast advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!" One of our customers added, "If I wanted that kind of abuse, I would have called my ex-wife."

If you want the right telescope, you need more than a camera store clerk with a price list, a surly attitude, and a wild guess.

What you *really* need are people who will take the time to listen to what *you* need, people with years of experience using and selling telescopes, people who can help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. We don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

We've been helping people choose the right telescope since 1979. We have the experience to help *you* pick the scope that fits your needs . . . *and your budget* . . . from the many Meade, Celestron, TeleVue, Takahashi, and Questar telescopes we stock at discount prices from $99 to $27,995. (We had 781 telescopes *in stock* as we wrote this on 4/2, and 1100+ on order.)

astronomics. No hard sell. No guesswork. Just honest advice, the *right* scope, and a good price. Call us at (405) 364-0858 and find out for yourself.

We buy Meade by the ton . . . literally!

The day before this copy was written, we received 305 cartons from Meade – *3¼ tons* of scopes and accessories in one shipment. We don't know of many other dealers – if any – who regularly receive, or actually stock, Meade products in those quantities . . . *no matter what they claim.* But we do. Meade telescopes, binoculars, eyepieces, filters, Magellan computers, Barlows, off-axis guiders, illuminated reticle eyepieces, counterweights, T-adapters, tele-extenders – we keep them all in stock.

We buy Celestron by the ton, too!

The week this was written, we received 9791 pounds of Celestron scopes and accessories in a single shipment – 21 pallets, a full trailer load. The week before, we got a separate 3950 pound shipment from Celestron. We have hundreds of Celestron scopes in stock for immediate shipment, plus accessories galore. We don't know of many other telescope dealers – if any – who order and stock Celestron in those quantities. But we do.

Because we buy in large quantities, we can take advantage of special buys – extra savings that we pass on to you.

We stock Pentax eyepieces.

From 5.2mm to 40mm, we stock all the Pentax wide field (55°-65°) long eye relief (20mm) ultra-premium ED glass eyepieces . . . all at *very* unpremium prices.

5.2 or 7mm 1.25" 65°	\$259^{00}
10.5, 14, or 21mm 1.25" 65°	\$249^{00}
28mm 1.25" 55°	\$239^{00}
40mm 2" 65°	\$259^{00}

Meade LX200 scopes now cost $500 less!

Meade 7" LX200 **$2795**

Great values at their former prices, Meade LX200 fully computerized go-to scopes are now spectacularly affordable with a price cut of $500 each! It doesn't matter whether the right scope for you is an 8" to 12" aperture **LX200 Schmidt**, or the 7" **LX200 Maksutov** shown to the right, Meade has priced each one at $500 below what it cost only a few short weeks ago.

8" LX200 SCTs are now only $2295. The best-selling 10" LX200 SCTs are now only $2695, the same price as a competitor's 8". The 12" LX200 SCT is down to $3995, while the 7" LX200 Maksutov shown above is only $2795. If Meade is shipping it for a dealer to keep in stock, the chances are good that we *have* it in stock.

Meade prices are about the same anywhere you call. So why order a Meade product from a dealer who charges your credit card, then makes you wait and wait until he finally gets around to ordering what you want? Not when you can usually get the Meade you want . . . right now . . . at the right price . . . right here at ***astronomics.***

We have 110 Meade ETX-125s in stock!

Meade 5"
ETX-125EC
$895

At the time this was written (4/4), we had 110 ETX-125EC 5" Maksutov-Cassegrains in stock, with 450 more scheduled for delivery before the end of the year.

With more than 200 sold during the first three months of this year, the ETX-125EC is one of our best-selling scopes.

And we don't just have scopes. We have Autostar computers, hard cases, tripods, eyepieces, electric focusers, filters, camera adapters, and more. If it's a Meade accessory for the ETX-125EC – or any Meade scope – chances are good we have it in stock.

Special Celestron 8" Dob package price!

Celestron
8" Dob
package
$???

We've perked up more than 50 of the 8" Celestron Dobsonian reflectors we have in stock by adding a Telrad finder, a 10mm SMA eyepiece (it already comes with a 25mm), and a 2x Barlow. Then we priced the entire package at . . . sorry, but you'll have to call us at (800) 422-7876 to discover our low price that's about 61.48% lower than the normal total list of $1035.95.

3-day air shipping at no extra cost!

We now ship by three-day air UPS from our warehouse to our East and West Coast customers at no extra charge above our regular shipping (except for Dobsonians, dewshields, and scope cases). No matter where you live in the 48 continental United States, your order should arrive by the third business day after we ship it. However, UPS cannot guarantee 3-day delivery in the event of bad weather or during peak seasons, and UPS service guarantees do not apply to this limited time free upgrade if shipments are delayed.

A fully-computerized 8"go-to scope for only $1899? *Amazing!*

You read that price right. Only $1899 for a fully-computerized go-to 8" telescope. Even better, the new **Celestron NexStar 8** can be powered by AA flashlight batteries. You're never tied down to an AC power outlet or a heavy rechargeable battery pack.

The **NexStar 8** puts sharp, bright f/10 Schmidt-Cassegrain optics into a sleek metal housing that brings go-to scopes into the 21st century in style!

Celestron
NexStar 8,
$1899

The NexStar's standard computer hand control stores in a recess in the scope's rigid single metal fork arm (and operates while stored there, as well as when it's undocked and handheld at the end of its coiled cord). The computer quietly moves the AA battery powered NexStar at a fast 6.5° per second to 18,473 stars and objects, all of the non-stellar deep space objects that can be seen in a scope this size. The computer also takes you on guided tours of the most spectacular deep sky objects visible on the night you observe. Standard equipment includes electric slow motion controls; a 40mm NexStar Plössl eyepiece; and a non-magnifying long eye relief Star Pointer red dot finder that's ideal for eyeglass wearers. An AC adapter is standard, not a costly option.

You can experience the heavens only a few days after you order a **NexStar 8** from ***astronomics!*** With two dozen in stock and over 400 scheduled for delivery over the next few months, chances are good we have one available for you.

Our free catalog helps you pick the right Meade, Celestron, Questar, Takahashi, or TeleVue scope.

For detailed information on individual products, visit our Web site. Or call us at (405) 364-0858, or e-mail us, for your *free* copy of our catalog AST. It covers all the scopes and accessories we stock – from Bushnell, Canon, Celestron, JMI, Lumicon, Meade, Pentax, Questar, Rigel Systems, SBIG, Software Bisque, Takahashi, TeleVue, and more. We'll include our 8-page guide on how to pick the right scope and your discount prices on the 1000+ products we carry. (Sorry, U. S. sales only.) The catalog is yours for only the cost of a one minute phone call. The information we send will make it the most useful minute you'll ever invest in astronomy.

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We'll sell you the *right* telescope.

The right scope might be a TeleVue.

TeleVue TV-85, in stock, **$1995**

Hardly a week goes by that TeleVue doesn't send us copies of new warranty cards from some of our customers – to let us read the glowing comments the customers wrote about the TeleVue scopes they bought from us. But satisfying our TeleVue customers is nothing new, because we've come to expect nothing but praise for TeleVue scopes.

The short focal length of TeleVue's ultra-premium refractors give you an observing flexibility many other scopes lack. Each has the ability to go from very low power wide angle views (as low as 9x in some cases, with a wide 5.7° field) to very high power observing, all without losing optical quality (one test report said they used an amazing 89x per inch of aperture on the Ranger, the least expensive TeleVue).

Pronto, **Ranger**, the **TV-85** and **TV-101**, the **Renaissance** – all TeleVue refractors are built to the same uncompromisingly high optical and mechanical standards. At the time this was written (3/31), we had 31 TeleVue scopes in stock and 45 more on order.

All TeleVue eyepieces are in stock

We also stock TeleVue eyepieces, Barlows, and accessories. Plössl, Panoptic, Nagler, Radian, Powermate, Paracorr, Starbeam, Tele-Pod, Gibraltar, Qwik-Point, or BinoVue – we carry them all. If it's a TeleVue product, chances are good we have it in stock.

$300 below dealer cost!

Canon

$\$799^{95}$

"Truly a quantum leap in binocular observing." That's how *Sky & Telescope* reviewed the **Canon 15 x 45mm** image-stabilized binoculars. They also said "astounding . . . supercrisp . . . particularly impressive was how well these binoculars compared to much larger apertures . . . " No shake, no blur, no jittery images during hand-held, rock-solid, astronomical observing. We bought a bunch, and our sale price is actually $300 below normal dealer cost. We have less than 50 still available at this price.

It might be a Questar.

For many people, the thought of a 3.5" scope that *starts* at $3399 is enough to curl their toes. But for those who want the best small telescope made, $3399 is a bargain.

Questar 3.5" Standard
$3399

Solar filters for eyepiece and finder, built-in Barlow, two ultra-premium eyepieces, a velvet-lined hard case, a star chart on the slide-on lens shade with a Moon map beneath – all are standard on a Questar . . . and unavailable from the competition.

Want a Questar, the premier portable telescope? We stock them.

Special pricing on Meade DS scopes.

Meade 5" DS127EC
$399

We have some limited time special pricing on the new Meade DS scopes that take the guesswork out of finding deep sky treasures. Each DS scope we stock comes complete with #492 dual axis DC drive motors and hand control for electronic command of the telescope's motion (they're usually optional on camera store and mall store versions). Each scope allows you to add an inexpensive ($99.95) optional Autostar computer to automatically slew the scope to deep space objects and track them flawlessly.

For a fully-computerizable telecope that will take you on a first-class tour of the heavens, but won't break your bank account, it's hard to beat the Meade DS scopes we stock.

DS80EC 80mm refractor	**$375.00**
DS90EC 90mm refractor	**419.00**
DS114EC 114mm reflector	**349.00**
DS127EC 127mm reflector	**399.00**

We have 58 Celestron NexStar 5s in stock!

At the time this was written (4/4), we had 58 Celestron NexStar 5" f/10 go-to computerized Schmidt-Cassegrains in stock for immediate shipment.

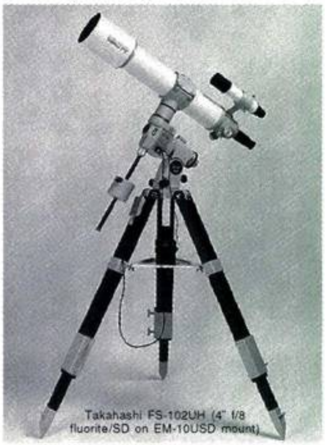
The NexStar 5 has the same built-in 18,473-object database computer as the NexStar 8 on the previous page. It has the same penlight-battery DC operation, the same sleek 21st century styling, the same standard equipment AC adapter and eyeglass-friendly Star Pointer finder. And it's all in a package that's supremely portable and user-friendly.

NexStar 5
$1199

Or it could be a Takahashi apo.

While many people swear *at* the long delivery times quoted by some premium refractor manufacturers, most knowledgeable astronomers swear *by* the unsurpassed optical quality and fast delivery of the Takahashi apochromatic refractors we keep in stock.

From the 2.4" **FS-60C** to the 5" **FS-128**, we stock Takahashi fluorite/special dispersion glass apochromatic doublet refractors, mounts, and accessories – so we can deliver scopes *fast.* We can also special order larger scopes with 1-3 month delivery times. Why wait for 1-3 *years* to get your apo refractor or mount from another manufacturer? You can be usually be viewing through a truly fine Takahashi apo only a few short days after you order from us.



Takahashi FS-102UH (4" f/8 fluorite/SD on EM-10USD mount)

We stock complete Takahashi apo scopes on USD mounts with dual-axis 50x sidereal slewing, as well as apochromatic optical tubes to install on your own mount.

We also stock the amazing Takahashi **FSQ-106** 4" dual fluorite lens 4-element f/5 apo refractor. It's both a visual scope and 4" focuser medium format astrograph. We had *8* in stock as this was written on 3/31.

Also in stock is the unique Takahashi **CN-212H** 8.3" reflector that converts from an f/12.4 classical Cassegrain reflector to a very fast f/3.9 Newtonian for both visual observing and wide field astrophotography.

If you want an apo, and want it *now*, it's Takahashi from ***astronomics***.

Dealer cost pricing!

These limited quantity sale items are all priced at dealer cost or below.

8" Celestron Solar Filter: full aperture mylar fits all 8" SCTs, $144 list	**$72.00**
24mm Celestron Ultima Eyepiece: top-rated 1.25" series, $158 list	**$67.50**
20mm Celestron Plössl: with free rubber eyeguard, $78 list	**$29.50**
Uranometria 2000.0, Volume 2: charts cover +6 to -90° dec, $39.95 list	**$24.95**
Deep Sky Field Guide to Uranometria: covers whole sky, $49.95 list	**$34.95**

Or maybe it's this 8" *astronomics* exclusive that saves you over 50%!

~~$2868 list~~
$1349

CELESTRON

Celestron C8 Special Edition, an astronomics exclusive (shown with optional dec motor)

Our 8" Celestron **C8 Special Edition** is built for us by Celestron, exclusively to our specifications. *No other telescope dealer has it.*

The **C8 Special Edition** consists of an 8" Schmidt-Cassegrain telescope with sharp Starbright true-multicoated f/10 optics and all the most-wanted features and options. Big setting circles, dust covers, and manual slow motion controls are standard equipment. Not only do you get an accurate sidereal rate DC drive that's powered by an ordinary 9-volt transistor radio battery for true cordless operation in the field (battery included) *but you also get separate power adapters for both 110 Volt household AC power in the backyard and 12 Volt DC car battery use in the field.*

You get a separate wedge with azimuth adjuster and a heavy duty *adjustable height* metal tripod with 2" diameter steel legs. The finderscope is a big 9 x 50mm. You get *two* Celestron Plössl eyepieces – a 26mm (78x) *and* a 10mm (203x). Both have removable rubber eyeguards, an ***astronomics*** exclusive. You also get a Moon filter and a copy of Celestron's TheSky Level 1 CD-ROM star charting software for your PC.

You won't find this exclusive package of the most-wanted features and accessories on any other Celestron telescope. And you won't find any other telescope dealer with anything approaching this unique Celestron package at this low price. ***It's an astronomics exclusive!***

> I am compelled to write and let you know how impressed I was with the information you sent me. I had called your toll free number to request a catalog. What I received was a course in astronomy. It was comprehensive and well written, yet succinct and to the point. I thought I knew a little about astronomy, and I did. I have now received the advanced course. Thank you.
>
> **Customer Quote of the Month #100**

20 x 80mm Celestron binoculars for $259!

We bought all of Celestron's 20 x 80mm Standard Giant astronomical binoculars and are closing them out at their lowest price ever. Quantities are *very* limited at this $259 price. No bells and whistles, just big optics at a little price. An optional tripod adapter is available for $24.

24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com
Our multiple award-winning Internet address: www.astronomics.com

Our phone lines are open 10 to 7 CST, Monday thru Friday, and most Saturdays from 12 to 5.
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ask Astro

Lunar Eclipses, NGC Objects, Expanding Spacetime

Q: The moon was always visible during the January 20 lunar eclipse. Why can we see the moon if it's in Earth's shadow? — *Kevin Kehoe, Great Lakes, Illinois*

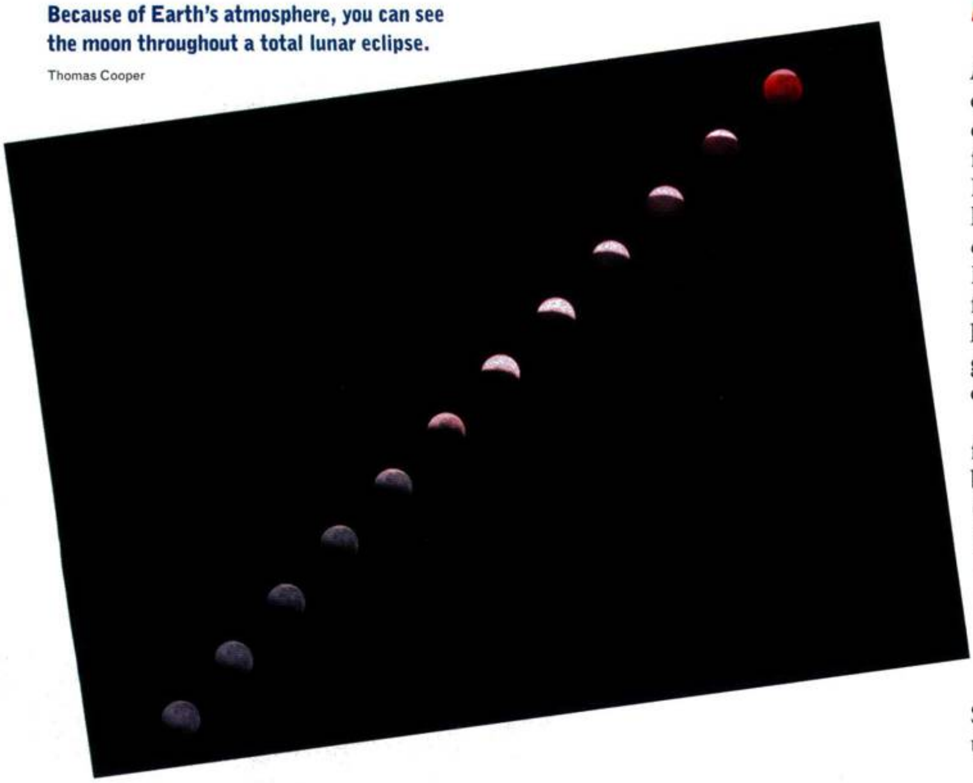
A: For those who have never noticed the moon's color during totality, July may offer you another chance. On Sunday the 16th, the second total lunar eclipse of 2000 will be visible. Residents and visitors across the Pacific Ocean (including Hawaii), in eastern Asia, Australia, and New Zealand will have the opportunity to witness one of nature's great spectacles.

You can credit Earth's atmosphere with providing an orangish color to the moon during an eclipse. The atmosphere acts like a filtered lens. It bends red sunlight into our planet's shadow and scatters out blue light. It's the same reason why sunrises and sunsets appear reddish. If Earth were an airless planet, its shadow would be pitch black and the eclipsed moon would be invisible.

If you were an astronaut standing on the moon during totality, you would see Earth eclipsing the sun. Earth would appear as a dark disk surrounded by a brilliant red ring — our atmosphere glowing with the light of all the planet's sunsets and sunrises. It's this light that we see bathing the moon during totality. — *Richard Talcott, associate editor*

Because of Earth's atmosphere, you can see the moon throughout a total lunar eclipse.

Thomas Cooper



Q: What is spacetime itself expanding into? — *Cephus Head, San Diego, California, and Richard Bach, Garland, Texas*

A: This is a very good question that has a disappointing answer. Simply put, spacetime isn't expanding into anything. Spacetime is not expanding into a preexisting space because the expansion of the universe creates space and time. The universe is defined as "everything that exists," so there is nothing outside of our universe into which it can expand. If other universes exist (see "Just 6 Numbers," page 54), they are disconnected from our own universe so our universe is not expanding into them.

If this is difficult to conceptualize, imagine yourself as a perfectly flat (i.e. two-dimensional) creature. Your entire universe is the surface of an expanding balloon. You would not "see" the surface of the balloon expanding into something. Instead, you would only see the two-dimensional surface of the balloon expand. In the case of our universe, our three-dimensional space is expanding, and we live in that same three-dimensional space. So from our three-dimensional perspective, it makes no sense to say that the universe is expanding into anything. — *Robert Naeye, senior editor (Robert thanks University of Michigan physicist Fred Adams for his help)*

Q: What are the easiest NGC objects to see in a small telescope? — *Lance Leblang, Peoria, Arizona*

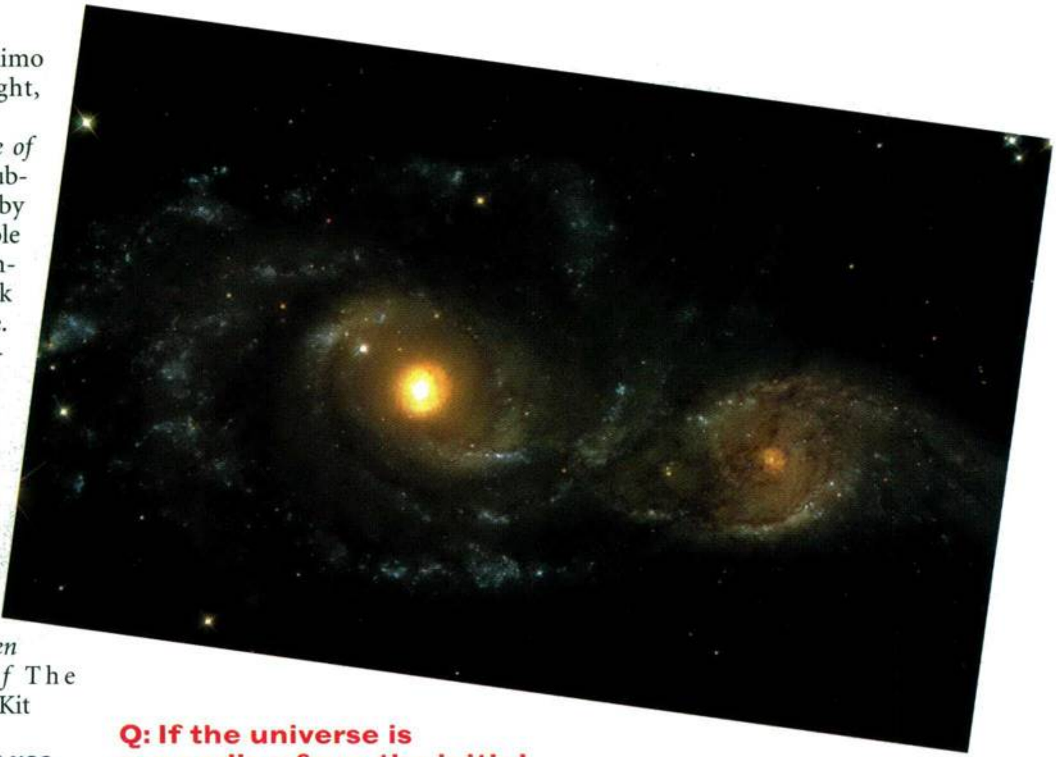
A: For Northern Hemisphere observers, arguably the finest NGC object not listed in Charles Messier's famous catalog is the twin entry of NGC 869 and NGC 884 — better known as the Double Cluster. Technically, the Double Cluster lies in Perseus, but it is most easily found a few degrees southeast of the well-known "W" of Cassiopeia. This glittering pair of clusters is a naked-eye object practically year-round.

The spring sky is loaded with many fine non-Messier galaxies, my favorite being NGC 4565, an edge-on beauty in Coma Berenices. It's not a cinch to find, but it's easy on the eyes. In the summer, gaze at the Scorpius Jewel Box, whose dazzling central cluster is NGC 6231. Each autumn, I turn my scope to the huge, nearly edge-on galaxy NGC 253 in northernmost Sculptor. This dusty spiral might show up in your finderscope. In winter, don't miss NGC 2392, the Eskimo or Clown-Face Nebula, a bright, bluish planetary in Gemini.

The *New General Catalogue of Nebulae and Clusters of Stars*, published in 1888, was compiled by John L. E. Dreyer of the venerable Armagh Observatory in Northern Ireland. The original work listed 7,840 clusters and nebulae. Over the next 20 years, supplements called the *Index Catalogues* (IC) added 5,386 more entries to the original list.

By the way, the prefix "New" was chosen because the NGC was considered an expansion of John Herschel's *General Catalogue of Nebulae*, which preceded the NGC by about 20 years. — *Ken Hewitt-White, author of* The Holographic Night Sky Book & Kit

From top to bottom: Some of the best NGC objects include NGC 4565, NGC 253, and NGC 2392 (the Eskimo Nebula). Top and middle: Bill and Sally Fletcher, Bottom: Jack Newton



Galaxies NGC 2207 and IC 2163 are gravitationally disrupting each other, although they are not colliding. Such interactions are common in groups and clusters of galaxies.

Hubble Heritage Team (NASA/STScI/AURA)

Q: If the universe is expanding from the initial point of the Big Bang and galaxies are like raisins in rising bread, each one becoming more distant from others, how then can galaxies collide? — *E. A. Johnson, Butte, Montana*

A: Although space is expanding, not every galaxy moves away from every other galaxy. That's because most galaxies belong to gatherings called groups or clusters. These congregations are held together by gravity, which overpowers the expansion of the universe. As galaxies move around within a group or cluster, they can easily collide.

Groups are small gatherings, the celestial equivalent of villages. They typically have a few bright galaxies and a few dozen dim ones. Clusters are far grander, the celestial equivalent of cities, crammed with hundreds or thousands of galaxies.

As an example, consider the Milky Way's group, the Local Group. The Local Group houses 35 known galaxies, most residing within 3 million light-years. The gravity of these galaxies prevents space from expanding, so if astronomers observed only these galaxies, they'd never know the universe is expanding.

Within the Local Group, galaxies have collided and will do so again. Most Local Group galaxies orbit its two giants, the Andromeda Galaxy (M31) and the Milky Way. The Milky Way has torn apart a small galaxy in Sagittarius that strayed too close, and billions of years from now, two other Milky Way satellite galaxies — the Large and Small Magellanic Clouds — will spiral into our galaxy. Several billion years in the future, Andromeda and the Milky Way may smash into each other, with the two monster galaxies possibly merging to form an even more colossal entity.

Astronomers start to see the expansion of space about 4 million light-years from the Local Group's center of mass. This is located between Andromeda and the Milky Way, slightly closer to Andromeda because it is more massive. — *Ken Croswell, author of* Magnificent Universe *(Simon & Schuster, 1999); http://www.ccnet.com/~galaxy*. ■

CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53187. Please tell us your full name and where you live.

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CLASS "A"

Color band - blue. Class "A" filters are made with the same premium quality polished glass and multi-alloy coating as Class "B". An additional steel alloy added to the coating process makes our Class "A" filters extremely scratch and fade resistant. Excellent for visual and photographic use. Light transmission is 1/1000th of 1%.

CLASS "B"

Color band - white. Class "B" filters are made with polished glass and multi-alloy coating. These filters offer great durability and will provide many years of service and enjoyment with normal use. Can be used visually and for photography. Light transmission is 1/1000th of 1%.

CLASS "C"

Color band - red. Class "C" filters are specifically coated to a lighter density (ND-4). They are for photographic use only. This filter is intended for use by professionals and serious hobbyists. Light transmission is 1/100th of 1%.

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2. Make check or money order payable to J.M.B. Inc. All foreign checks must be payable through a U.S. bank.
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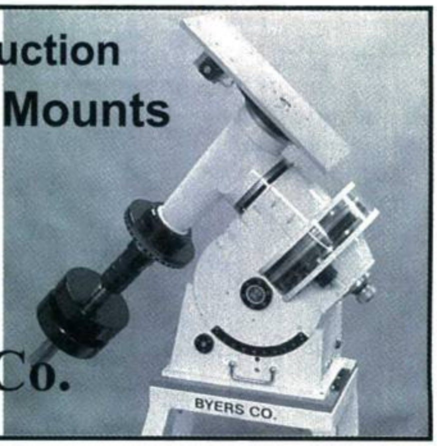

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New! **NGF-SE FOCUSER**

Manual version of JMI's famous zero-image-shift NGF-S focuser. Fits Meade and Celestron Schmidt-Cassegrain telescopes (SCT).

- **Extra fine control**, one rotation of the knob gives 0.39" travel
- **Low profile** adds less than 2-1/2".
- **Heavy duty**, carries 8 pounds.
- **Solid** anodized aluminum.
- **Focus lock**
- **2" output plus threaded output adapter.** All SCT accessories can be used.

CONTEST RULES: Send us your name suggestion for this revolutionary focuser, and if we choose your product name you will receive FREE an NGT-6 telescope (a $1,000 value—you only pay for the shipping.) Names should be short; acronyms are fine. Send more than one if you wish, but no more than five. Entries must be sent by mail (pls. no e-mail). In case of duplicates, the earliest postmark will qualify. Must be postmarked by 7/31/00. JMI's employees and families not eligible. Winner notified by 9/1/00. Suggested names not allowed: JMI Focuser, Reverse Crayford, Jim Burr Focuser. Offer void where prohibited.

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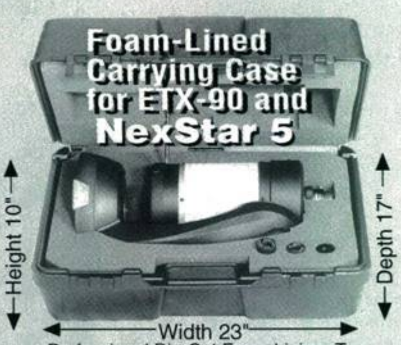

Foam-Lined Carrying Case for ETX-90 and NexStar 5

- Professional Die-Cut Foam Lining -Top & Bottom (No cubes to fall out).
- Compartments to hold eyepieces, hand controls, etc.

IMPORTANT:
The ETX-90 and the NexStar 5 can easily fit in the overhead compartments of airlines. Explain to your airline that this is expensive, delicate equipment and you should have no problem with carry-on.

NexStar 5	**$149.95** (\$8)

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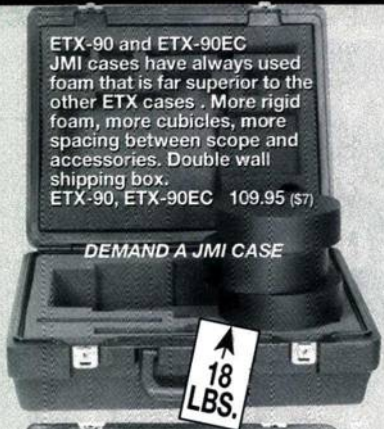
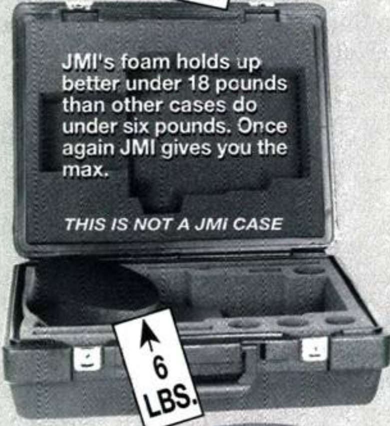


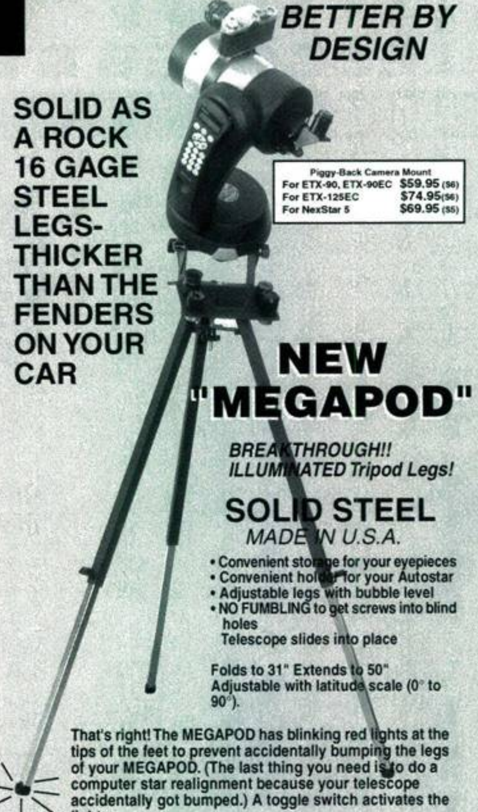
ETX-90 and ETX-90EC
JMI cases have always used foam that is far superior to the other ETX cases . More rigid foam, more cubicles, more spacing between scope and accessories. Double wall shipping box.
ETX-90, ETX-90EC 109.95 (\$7)

DEMAND A JMI CASE



JMI's foam holds up better under 18 pounds than other cases do under six pounds. Once again JMI gives you the max.

THIS IS NOT A JMI CASE



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BREAKTHROUGH!! ILLUMINATED Tripod Legs!

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- NO FUMBLING to get screws into blind holes
  Telescope slides into place

Folds to 31" Extends to 50"
Adjustable with latitude scale (0° to 90°).

That's right! The MEGAPOD has blinking red lights at the tips of the feet to prevent accidentally bumping the legs of your MEGAPOD. (The last thing you need is to do a computer star realignment because your telescope accidentally got bumped.) A toggle switch activates the lights.

MEGAPOD for ETX-90, ETX-90EC, ETX-125EC, NexStar 5 $229.00 (\$14)

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Solid aluminum design for all popular scopes starting at \$88. MOTOFOCUS upgrade for NGF Focusers \$100. Must be ordered together.

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NGF-DX3 2" with 1.25" adapter Lifts to 5 lb.	**$159** (\$7)
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NGF-mini3 1.25"	**$ 99** (\$7)
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NGF-S for SCTs - This special version of our NGF focuser fits directly onto 2" thread of Meade and Celestron 8" - 14" Schmidt Cassegrain telescopes.

NGF-S w/ built-in MOTOFOCUS Includes 2" - 1.25" eyepiece and T-Thread adapter and 2" threaded output adapters.	**$269 (\$7)**
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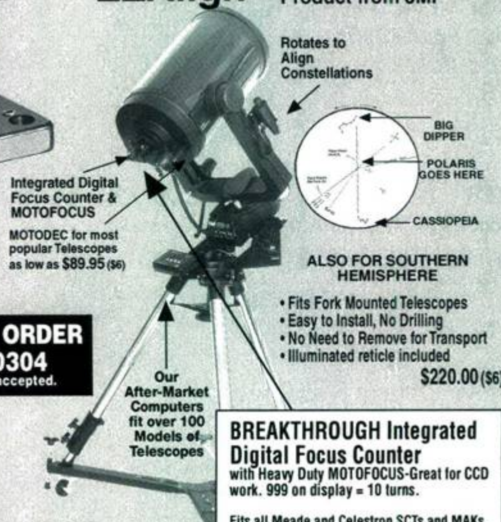
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NO SURFING FOR FOCUS MODE

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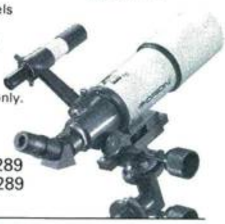

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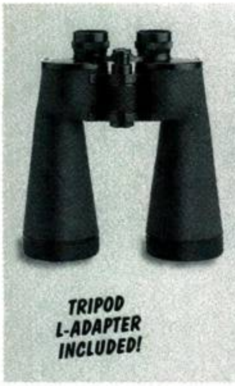

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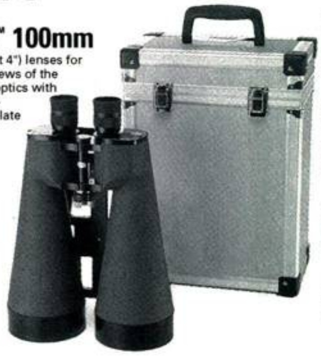

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Night Owl Optics, 307 Seventh Avenue, New York, NY 10001; phone, (212) 229-0297; fax, (212) 229-0298; website, http://nightowloptics.com. Night Vision Monoculars: *$225 to $500. The Night Owl Explorer NOCX3 ($300) is pictured.*

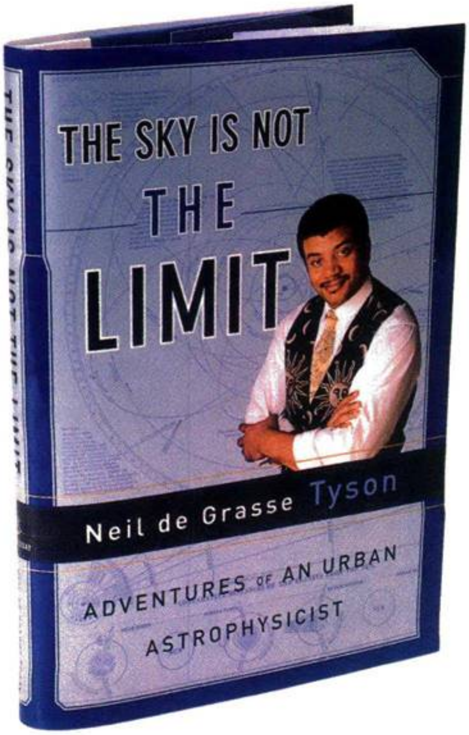
BOOKS

The Sky Is Not the Limit: Adventures of an Urban Astrophysicist

Neil de Grasse Tyson, 191 pages, Doubleday, New York, 2000; ISBN 0-385-48838-6; hardcover, $23.95.

▶ Neil de Grasse Tyson, inspired by the night sky at New York's Hayden Planetarium, declared, "I want to be an astrophysicist," when he was only 9 years old. In 1996, at 37, he became the planetarium's youngest director. His new book *The Sky Is Not the Limit: Adventures of An Urban Astrophysicist* tells the story of this journey.

He starts off in New York City, where he grew up in the Bronx, bought his first telescope, and attended the Bronx High School of Science. His narrative moves to life as an undergraduate at Harvard University (where he was a rower and wrestler) and to graduate school at the University of Texas and Columbia University. He describes an observing run at the Cerro Tololo Inter-American Observatory in the Andes Mountains, where he studied the bulge at the center of the Milky Way Galaxy. Tyson also reflects upon his present-day activities as lecturer, author, and research scientist at Princeton Univer-



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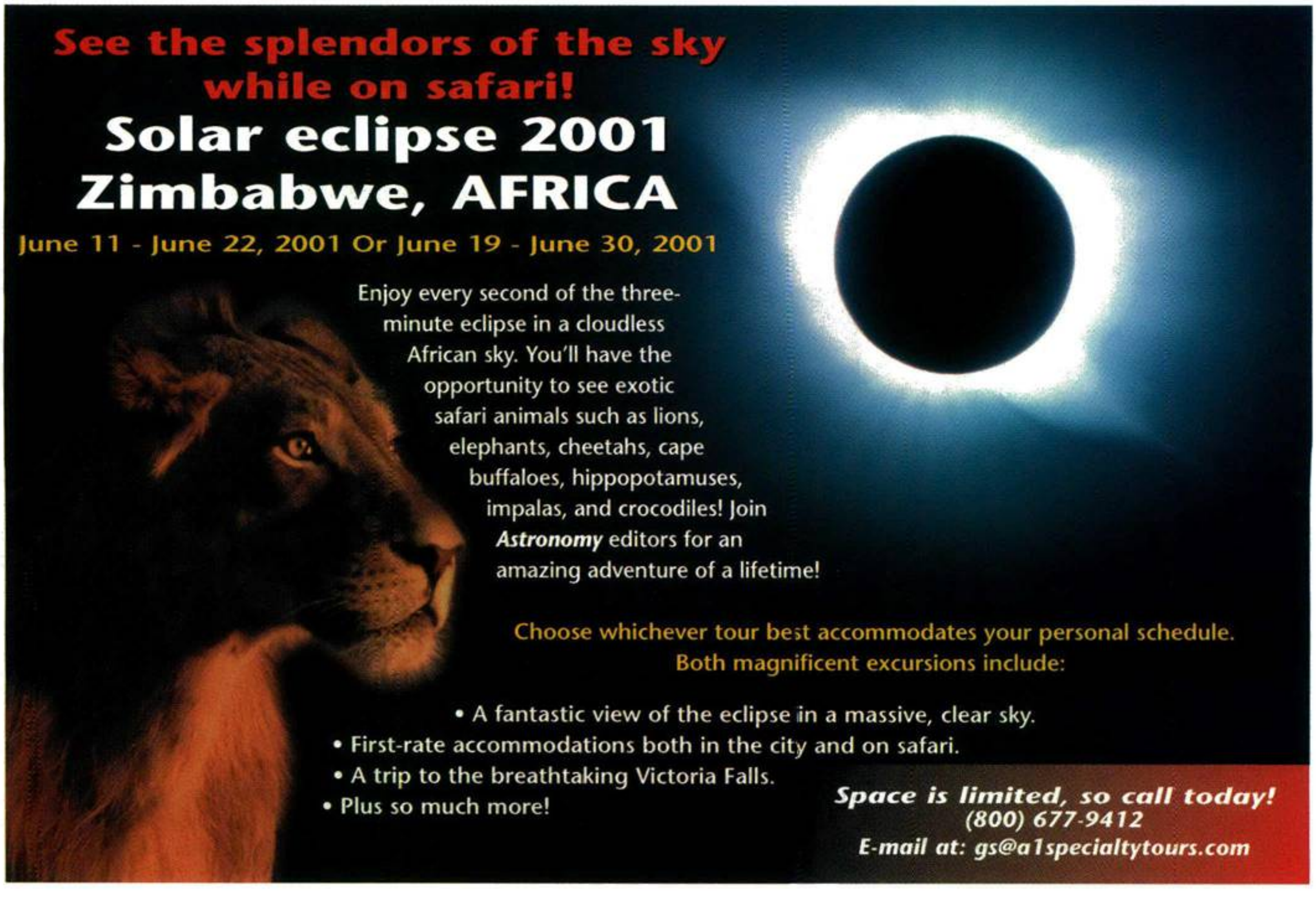

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sity. But what elevates this book from a straightforward memoir are the passages that reveal our world from his perspective — as a scientist and African-American.

Tyson speaks at length about scientific literacy — a topic dear to his heart. He wishes at least one critic would have declared, "Flying saucers traveling quadrillions of miles through interstellar space don't need runway lights to land on Earth," when reviewing the 1977 movie *Close Encounters of the Third Kind*. Tyson later adds, "I would have rejoiced had I heard just one critic say, 'A killer asteroid the size of Texas would have been discovered two hundred years ago, not two weeks before impact,' when reviewing the 1998 summer blockbuster *Armageddon*."

The chapter "Dark Matters" deals frankly with racial prejudice. In normal daily life, Tyson has trouble flagging down a cab in Manhattan. But prejudice also set up obstacles in his scientific career path. "I shortly came to the shattering awareness that few parts of society were prepared to accept my dream," he writes. "I wanted to do with my life what people of my skin color were not supposed to do. As an athlete, I did not violate society's expectations since there was adequate precedent for dark-skinned competitors in the Olympics and in professional sports. To be an astrophysicist, however, required walking a 'path of most resistance.'"

Tyson delves into religion in the final chapter. "Let there be no doubt that as they are currently practiced, science and religion enjoy no common ground," he writes. "The claims of science rely on experimental verification, while claims of religion rely on faith." Even though Tyson explicitly states that he has never seen a successful predication about the physical world that was inferred from any religious document, he writes, "I, like Ptolemy, am humbled in the presence of our clockwork universe. When I am on the cosmic frontier, and I touch the laws of physics with my pen, or when I look upon the endless sky from an observatory on the mountaintop, I well up with an admiration for its splendor."

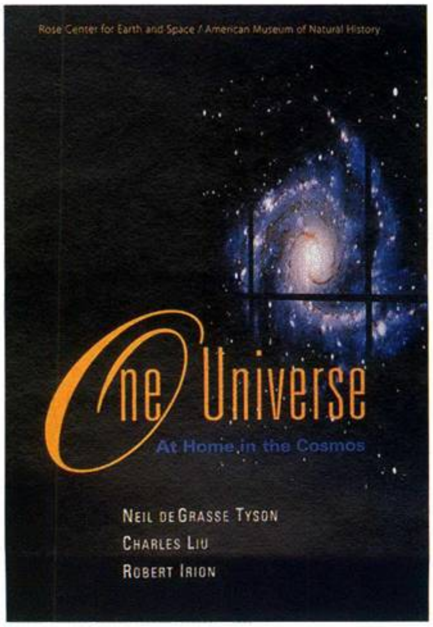
Despite Tyson's love for astronomy, this volume rarely touches upon his own research and new developments in the field. In addition, he says virtually nothing about his role in developing the New Hayden Planetarium at the Rose Center for Earth and Space. Still, told in simple parlance and at a casual pace, this book makes a valuable and enjoyable read for budding scientists, their parents, and their teachers. Scientists may also enjoy it as they relive common experiences. — *Beth Livermore, contributing editor*

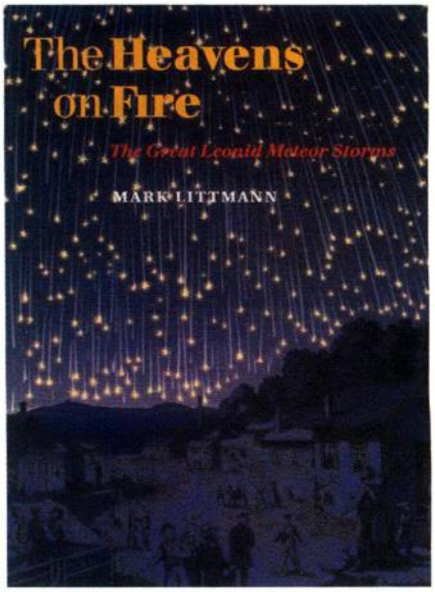
One Universe: At Home in the Cosmos

Neil de Grasse Tyson, Charles Liu, and Robert Irion, 218 pages, Joseph Henry Press, Washington, D.C., 2000; ISBN 0-309-06488-0; hardcover, $40.

▶ Anyone looking for a book that takes readers from everyday life to the edges of the universe and back needs to check out *One Universe: At Home in the Cosmos* by astrophysicists Neil de Grasse Tyson (author of *The Sky Is Not the Limit*) and Charles Liu, and science journalist Robert Irion (an *Astronomy* contributing editor). The mental journey is so painless that even vaguely interested page-turners will learn in spite of themselves.

Divided into four parts that tackle motion, matter, energy, and frontiers, *One Universe* manages to shed the reputation of most coffee-table books by being more than just a pretty face. Instead, expect a copiously illustrated journey through good science — although sometimes at too low a level for more sophisticated astronomy buffs — with solid examples that drive home even arcane points in a straightforward manner. Each new topic compels the reader onward. So pick it up and start reading anywhere — *One Universe* does not require front-to-back reading.





The Heavens on Fire: The Great Leonid Meteor Storms

Mark Littmann, 349 pages, Cambridge University Press, New York, 1999; ISBN 0-521-77979-0; paperback, $19.95.

▶ This 1998 book has been updated for its 1999 paperback release. Although the predictions for the 1998 and 1999 meteors are no longer relevant, the 2000 information is still valid. The majority of the text is devoted to a historical look at the famous November meteors. Both personal accounts over the last 200-plus years and scientific explanations are included.

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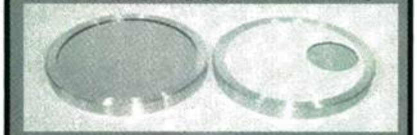

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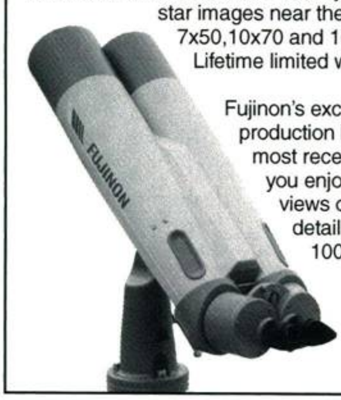

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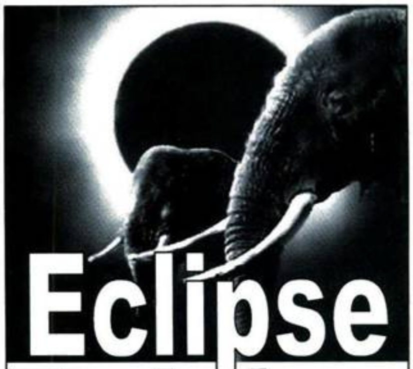

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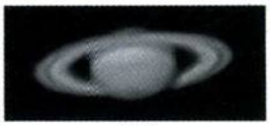

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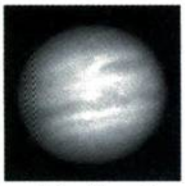

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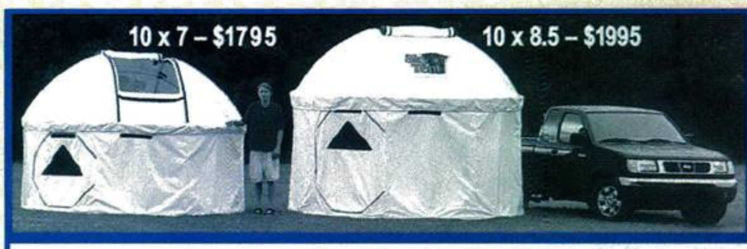

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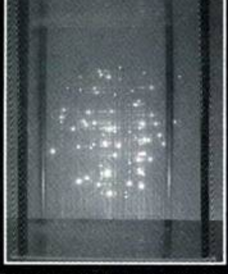

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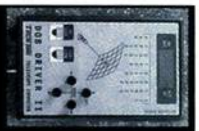
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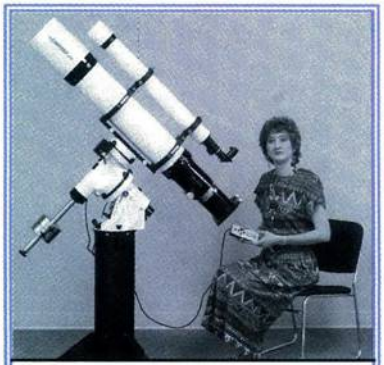
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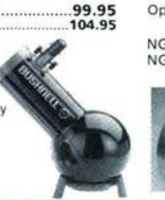

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Astronomy magazine and the Astronomical Society of the Pacific proudly present **UNIVERSE 2000 EXPO** in Pasadena, California, from **July 13 – 19, 2000.** This meeting features a range of presentations and discussions and incorporates "The Cosmos in the Classroom," a three-day symposium on teaching introductory astronomy to nonscience majors. Corporate event sponsors include telescope manufacturers, observatories, and related research facilities. Tours and social events are also scheduled. For registration information, contact the ASP Annual Meeting, 390 Ashton Ave., San Francisco, CA 94112; (415) 337-1100; fax, (415) 337-5205; e-mail, meeting@aspsky.org; website, www.aspsky.org/meetings.html.

For a lower-key star party, look to the northeast to the **Great Manitou Star Party (GMSP)** from **July 27 – August 2, 2000.** Presented by the Sudbury Astronomy Club with assistance from Science North and Laurentian University at Gordon's Park, Manitoulin Island, Tehkummah, Ontario, the GMSP gets you far away from city lights on the world's largest freshwater island. For a complete lodging list, call the Manitoulin Chamber of Commerce at (800) 698-6681. Contact Mark Oldfield, 1687 Carol Street, Val Caron, ON P3N 1H1, (705) 897-4518; e-mail, greatmanitou@hotmail.com.

JULY 1

Free Public Star Party

Sponsored by the Shreveport-Bossier Astronomical Society at the Ralph A. Worley Observatory south of Shreveport, Louisiana. Contact Cran Lucas, (318) 797-1524; e-mail, clucas@softdisk.com; website, http://www.lsus.edu/nonprofit/sbas/.

JULY 5 - 9

Star-B-Que, Eccles Ranch Observatory, Caroline, Alberta, Canada

Sponsored by the Royal Astronomical Society of Canada, Calgary Centre, Alberta. Contact Roland Dechesne, (403) 246-4498; e-mail, RolandD@cnrl.com; or Shirley Conway; e-mail, slconway@cbe.ab.ca.

Mark Oldfield

A Perseid meteor slashes through the trees on Manitoulin Island, Canada, in this time exposure.

JULY 7 - 9

Festival d'Astronomie Populaire du Mont Mégantic Notre Dame des Bois, Québec

For details and information regarding this 17th Annual event, please call the ASTROLab du Parc du Mont Mégantic, (819) 888-2941.

JULY 9 - 13

15th International Planetarium Society (IPS) Conference

IPS 2000: Planétarium de Montréal, Canada. For information, e-mail, info@planetarium.montreal.qc.ca; website, http://www.planetarium.montreal.qc.ca/IPS2000.

JULY 16 - 18

Society of Amateur Radio Astronomers Annual Convention

Contact Vince Caracci, (516) 798-8459; e-mail, vinhell@juno.com. For registration and information, contact Chuck Forster, 5420 Glenway Circle, Oregon, WI 53575.

JULY 19 - 22

Astrocon2000

Hosted by the Ventura County Astronomical Society at the Holiday Inn Ventura Beach, California. For information, contact VCAS/Astrocon2000, P.O. Box 982, Simi Valley, CA 93062; Wendy Calderon: (805) 583-5377; or VCAS Starline: (805) 529-7813; e-mail, astrocon2000@vcas.org; website, http://vcas.org/astrocon.

JULY 21

Hudson Valley Star Party

Sponsored by the Mid-Hudson Astronomy Association at Wilcox Park in Milan, New York. Comet LINEAR will be circumpolar. Campers contact Wilcox Park, 85 Sheafe Road, Wappingers Falls, NY 12590; (914) 298-4600. For club hotline and event information, call (914) 485-5669; or (914) 758-6305; e-mail, mhaa@geocities.com; website, http://jump.to/mhaa.

JULY 21 - 22

Cuyahoga Astronomical Association Annual Convention

Star party July 21. Convention to follow July 22 at Oberlin College, Cleveland, Ohio. Member of the Ohio Turnpike Astronomy Association. Speakers, observing, and more. For information, please contact Bob Wiersma, (440) 779-5852; or Albert Matyas, (440) 878-0258.

JULY 21 - 22

Mountain High Star Party

Yellowstone National Park. Daily talks by *Astronomy* editors and nightly observing sessions. For program information, contact (307) 344-2263.

JULY 27 - 29

Table Mountain Star Party

20th annual event near Ellensburg, Washington. Registration begins May 26th. Contact TMSP, P.O. Box 785, Puyallup, WA 98371; e-mail, Ms. Marcie Roundtree, lmround830@aol.com; or check the TMSP website, www.tmspa.com.

JULY 27 - 30

Weekend Under the Stars

Hosted by the Cheyenne Astronomical Society and the Laramie Astronomical Society and Space Observers at Foxpark, Wyoming. Contact Marty Curran (307) 635-5944; e-mail, mcurran@sisna.com; or Charla Wagner (307) 634-7312; e-mail, cwagne@missc.state.wy.us; website, http://users.sisna.com/mcurran/wuts.htm.

JULY 28 - 29

Annual Stellafane Convention

Breezy Hill in Springfield, Vermont. Contact Stellafane Convention, P.O. Box 50, Belmont, MA 02178; fax, (520) 244-5338; Wayne "Waynbo" Zuhl, Secretary, Springfield Telescope Makers; e-mail, STM-Secretary@home.com; website, www.stellafane.com.

JULY 28 - 29

Seventh Annual Montana Starwatch

Southwest Montana Astronomical Society. For information, please contact Mike Murray, Museum of the Rockies, 600 W. Kagy Blvd., Bozeman, MT 59717; (406) 994-6891; e-mail, mmurray@montana.edu; website, http://www.montana.edu/smasweb/.

JULY 28 - 31

Island Star Party 2000

Cowichan Valley StarFinders Astronomy Club, Vancouver Island, British Columbia, Canada. Contact Janet Curley, Treasure CVSF, #12, 2121 Tzouhalem Rd., Duncan, B.C. V9L 5J5; (250) 748-2919; e-mail, curley@islandnet.com; website, http://starfinders.cvnet.net.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or to cryback@astronomy.com. Look for additional events at http://www.astronomy.com.

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HYAKUTAKE

Comet Girl

Coed comet watchers find an unconventional way to share their enthusiasm.

▶ It was about 2:00 A.M. on a weekend morning, and I was driving home from a friend's place, minding my own business, when I saw two girls holding up a cardboard sign that read, "See the Comet. $.50." Not something you usually see at two in the morning.

Just to set the scene, it was in March 1996 (although not super cold as it sometimes can be in Wisconsin in the winter), and I was driving on a major street in downtown Madison on the isthmus. (Madison happens to be wedged between several lakes.) I knew Comet Hyakutake was supposed to be making an appearance sometime soon, but I didn't think it was here already, and more surprisingly, I never thought you'd be able to see it from downtown. Madison isn't Chicago or New York, but it has enough downtown lights to wash out the night sky.

I kept driving, but then I said to myself, "Self, it's 2:00 A.M. on a weekend morning. What better things do you have to do?" So I whipped around the block and pulled up in front of the girls and asked if they had a telescope, but they said no, they were just pointing it out to people. So I told them I'd park my car and be right over.

When I got there, they pointed it out to me, and, sure enough, there was

Above: Comet Hyakutake

LEO AERTS

(300mm lens at f/2, Tech Pan 2415 film, 10-minute exposure taken in 1996)

Below: NGC 7293, The Helix Nebula

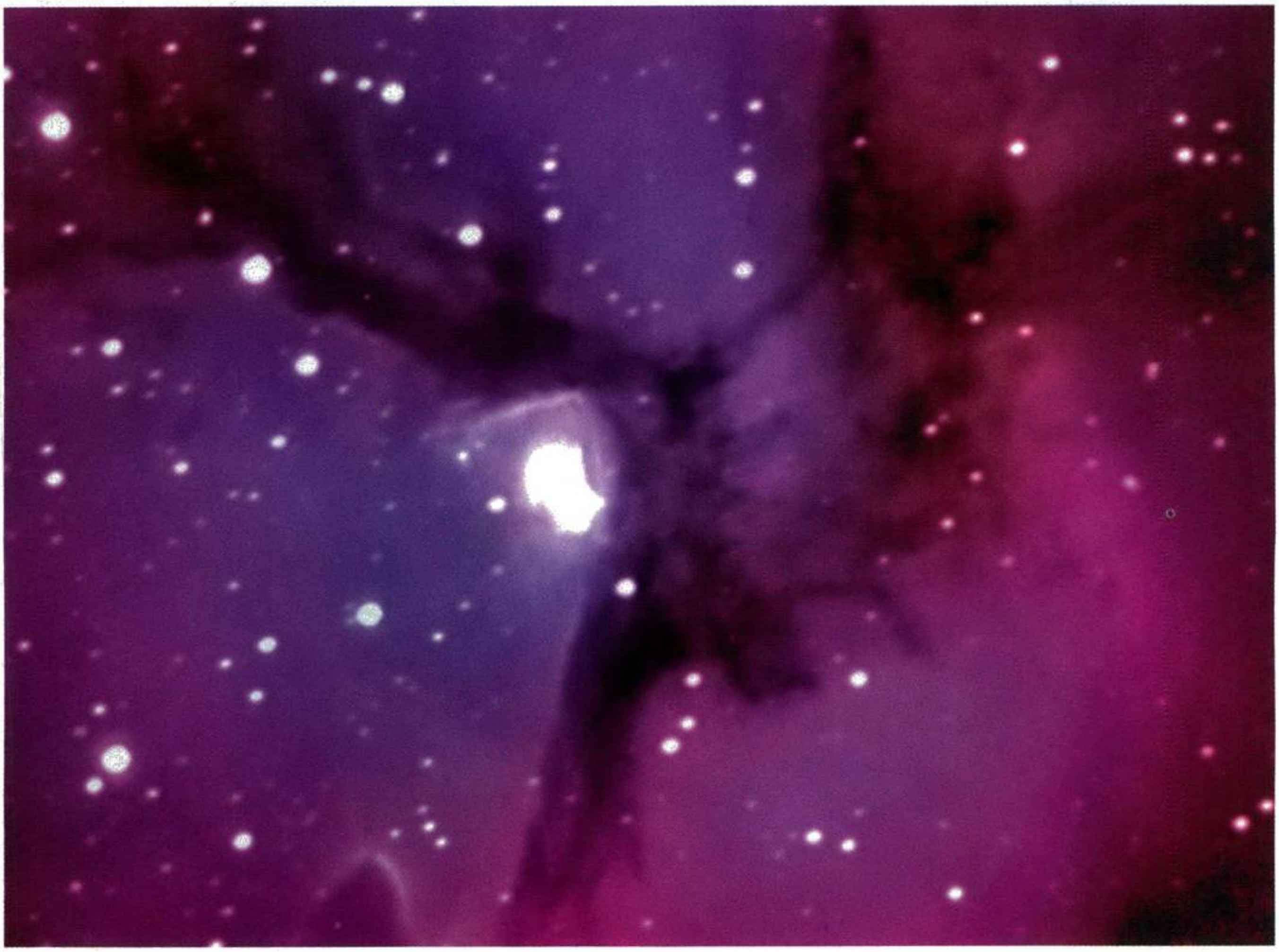
JOHN CHUMACK

(6-inch apochromatic refractor, ST-6 CCD camera, 35-minute exposure)

Below: M20, Inside the Trifid

NIK SZYMANEK AND IAN KING

(10-inch SCT, ST-7 CCD camera,
A07 adaptive optics system)



Hyakutake. I was surprised by how bright and easy that fuzzball was to find, especially near all the street lights. We could even see a bit of the tail.

As we stood talking and watching the comet with a couple of other passersby, one girl said her name was Joti (pronounced Jo-tee), which was East Indian for something like "Point of Light." I immediately rechristened her Comet Girl (I don't remember her friend's name). They told me that business had not been good. A few barhoppers had stopped, but there hadn't been much interest. I was the first motorist to stop. But Comet Girl wanted more people to be aware of this astronomical event, so she started going door to door to publicize it. She only stopped at houses where lights were on, but since Madison is a college town, and all the houses on this street were those of students, a few did come out to see the comet.

I eventually went home, got my camera, and took a few pictures. I even called up the late-night DJ at my favorite radio station and told him about the comet — he went on air to tell people it was out. My attempts to get him to pronounce Hyakutake correctly, however, proved futile.

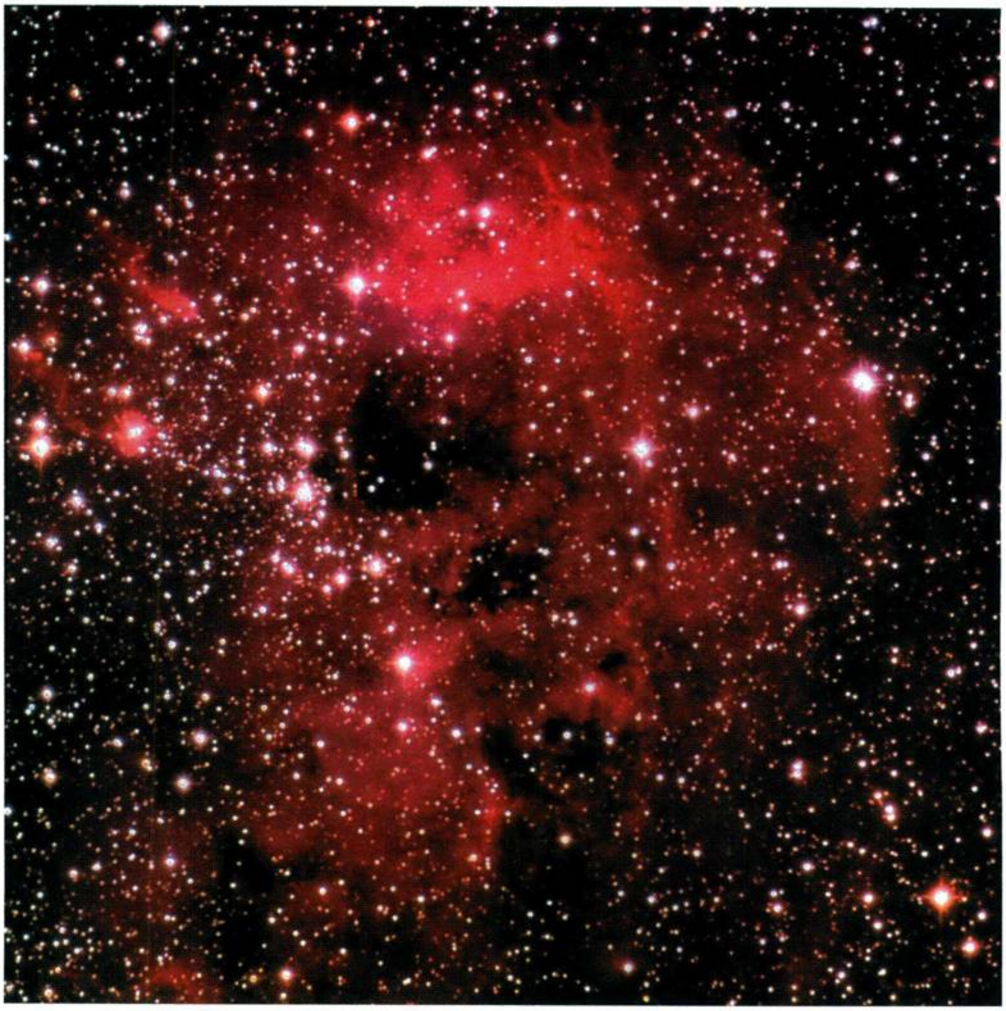
I was happy to have run across Comet Girl and her friend that night. Otherwise I might have missed Hyakutake altogether. And, just for the record, they did not take anyone's money, although if they tried it with Hale-Bopp later that year they may have come out alright. ◼

Mark Miller views the starry sky from the well-lighted city of Madison, Wisconsin.

M33, Pretty in Pink

BASTIEN CONFINO

(24-inch St-Luc Observatory telescope at f/3.9, HiSys44 CCD camera, 15-minute exposure)



Rosy Red IC 410

BRIAN LULA

(20-inch reflector at f/5, IMG1001E CCD camera, 9-minute red, 9-minute green, and 13.5-minute blue, and 13.5-minute infrared-absorption filter exposures)

NGC 6121

JAMES R. FOSTER

(11-inch SCT at f/11, Kodak PPF 400 film, composite of 35-minute and 25-minute exposures)

Crescent Glow

NELSON FALSARELLA

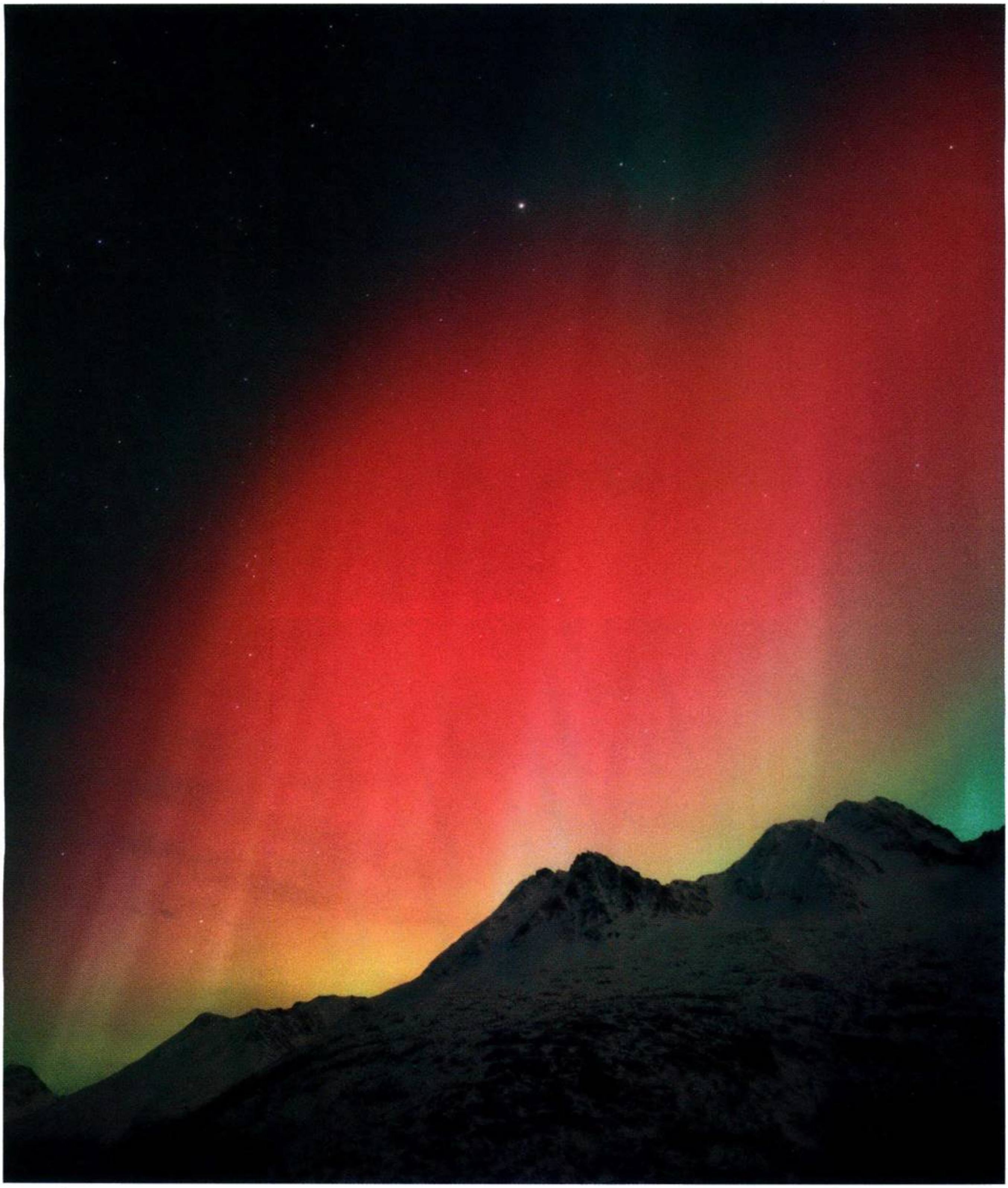
(8-inch SCT, Kodak Ultra ISO 400 film, 3-second exposure taken in January 2000)

The Moon and Venus Hold Court

IVAN DRYER

(105mm lens at f/2.5, Kodak VS film, taken February 2, 2000)

This month's best astrophoto



Multicolored Auroral Wall

MICHAEL KLENSCH

(50mm lens at f/1.7, Fuji Superia 200 ISO film, 10-second exposure taken February 10, 2000, from Skagway, Alaska) Aurora sightings are beginning to accumulate as solar maximum approaches.

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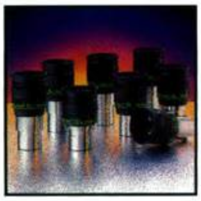
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Images by Jack Newton with the Meade 16" LX200 Schmidt-Cassegrain telescope, Meade f/6.3 Focal Reducer, Meade Pictor 1616XTE CCD Imaging Camera, and Meade 616 Color Filter System. *Clockwise from lower-left:* spiral galaxy (M83) in Hydra; nebulosity (NGC 1977) surrounding the star 42 Orionis; the Dumbbell Nebula (M27) in Vulpecula; detail of the Trapezium in the Orion Nebula (M42). Mr. Newton comments: "The combination of the blue-sensitive Pictor 1616XTE camera and the sharp spectral cut-offs of the Pictor 616 filters were essential to the success of this imaging series. Note the prominent H-II regions in M83 — regions rarely imaged even by professional telescopes."

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